

## ABSTRACT

Title of Document: THE IMPACT OF INSTRUCTION  
INCORPORATING CONTENT AREA  
READING STRATEGIES ON STUDENT  
MATHEMATICAL ACHIEVEMENT IN A  
COMMUNITY COLLEGE DEVELOPMENTAL  
MATHEMATICS COURSE

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When a student is not successful in mathematics, teachers frequently assume the difficulty lies within the student's mathematical ability or negative disposition towards mathematics, but the difficulty may lie with the student's reading comprehension (Draper, Smith, Hall, & Siebert, 2005; Kane, Byrne, & Hater, 1974). Many post-secondary students enter classrooms with limited knowledge, skills, or disposition for reading, and this can impact comprehension of their textbooks and other school reading materials (Snow, 2002). This is especially important since college-level work requires students to assume responsibility for independent learning by reading their textbook. Students have difficulty reading and comprehending the text in mathematics textbooks due to the textbook's unique structure, density, and vocabulary (Barton & Heidema, 2002; Idris, 2003). Incorporating content area reading strategies into classroom instruction may be a vehicle through which teachers can facilitate students' ability to learn from their mathematics textbooks (National Reading Panel, 2001; Siebert & Draper, 2008; Snow, 2002).

This study utilized a quantitative control-treatment design to investigate whether the incorporation of reading strategies into the instructional practices of a community college's prealgebra developmental mathematics course would effect students' overall mathematics achievement in the course as measured by standardized course assessments and the course passing rate. Participants were 179 community college students enrolled in a prealgebra developmental mathematics course during a spring semester (13 instructors; 16 sections). Student demographic data, as well as instructor professional and demographic data served as control variables. Observations of selected treatment- and control-class meetings, and interviews with instructors informed qualitative context.

Hierarchical linear modeling revealed no statistically significant difference in performance on standardized measures or course passing rate between students in the treatment and control sections. The qualitative observations and interviews indicated limited fidelity of implementation of the reading strategies across treatment sections. HLM results suggest a difference in student performance between levels of implementation. Weaker implementation of the reading strategies was associated with lower student performance, as compared to that of high treatment implementation or control sections. These findings indicate that organized professional development is necessary if community college faculty are expected to incorporate reading strategies into their instructional practices.

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READING STRATEGIES ON STUDENT MATHEMATICAL ACHIEVEMENT IN A  
COMMUNITY COLLEGE DEVELOPMENTAL MATHEMATICS COURSE

By

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Dissertation submitted to the Faculty of the Graduate School of the  
University of Maryland, College Park, in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy  
2011

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## ACKNOWLEDGEMENTS

I have thought about what I would write here several times over the last two years, I have so many people to thank for guiding me to this path and supporting me along the way that I was not sure where to start or how to approach this. I finally decided to start at the beginning. First, my parents and grandparents were always very big proponents of education; it was understood that we would all go to college. I remember my dad telling me that I needed to major in an area that would lead to employment after I finished a Bachelor's degree. I majored in mathematics, and joined the U.S. Air Force. After my time in the Air Force, I returned to school for a Master's degree. It was there that I had a professor who talked to me about pursuing a doctorate. I was surprised that someone of his stature thought I had the qualifications to pursue a doctorate. I did not follow the path he suggested, but it was always in the back of my mind that someone thought I could do this and that maybe one day I would. Several years later, I was teaching at a community college and finally found the job that I "didn't mind getting out of bed in the mornings to go to." I loved teaching mathematics. It was at this time that the idea of a doctorate resurfaced for me. I felt that I needed to learn more about how students learn mathematics and how to teach better. A colleague at the community college suggested the mathematics education program at the University of Maryland and the rest is here in these pages.

I never realized that I had a passion for reading issues in mathematics and for that realization I thank Dr. Anna Graeber for her course in mathematical misconceptions. One topic in the course was about the mathematical misconceptions which reading and vocabulary may cause for students. This is when Dr. Marilyn Chambliss, a reading

specialist, took me under her wing and introduced me to the topics of reading and literacy. She also allowed me to work with her to teach a course on reading in the content area for pre-service secondary teachers. I worked specifically with the pre-service secondary mathematics teachers. Thank you both for helping me learn about reading issues in mathematics.

During this journey, Dr. Patricia Campbell has been extremely influential and valuable to me. She is my advisor and committee chair, and I could not have asked for better and I thank her. I have also worked with her on a large-scale research study for years. I learned and experienced so much from being part of this study that I was able to draw upon it to guide my study design. I also thank Dr. Robert Croninger for helping with the HLM models for the quantitative portion of this study. I appreciate his patience and gentle guidance, as dealing with my raw data set was not as easy as the clean data sets that students usually work with. Dr. Lawrence Clark contributed to this study in ways he does not realize. He also works with the large-scale research study and by listening to the types of questions he asked and the discussions he brought forth, I found value. He caused me to think more deeply about effects and causes of my findings.

I also feel the need to thank my friends and family. I did not spend as much time with them as I had before this journey began and at times was not able to attend celebrations. My friends are still with me and that says more about them than me. Thank you all. And finally, my husband, what can I say, except he has been incredible. Nothing about this journey would have been possible without him. He provided encouragement and support in so many ways and took on many extra responsibilities so I had time to do school work. All I can say is thank you and I love you.

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## **Chapter 1: Introduction**

This study seeks to analyze the impact of instruction incorporating content area reading strategies on student mathematical achievement in a community college developmental mathematics course. Many high school graduates enter college with poor reading skills (American College Testing [ACT], 2008; Porras, 1994). Students learn how to read while in elementary school, and teachers of subsequent mathematics classes assume and expect their students to be able to read and comprehend the textbook on their own (Porras, 1994). That may be a reasonable assumption, but the skills taught in elementary school reading classes are not adequate for the reading of mathematics and, more importantly, for comprehending the material in mathematics textbooks as students progress through school. A limited transfer of reading skills occurs from the narrative prose of elementary school-level novels to the expository prose of mathematics textbooks at any level (Smith & Kepner, 1981). This may be critical as publishers of mathematics textbooks have been adding longer passages of verbal text which increases the reading load for students (Barton & Heidema, 2002). In mathematics specifically, students can have difficulty reading and comprehending the mathematics in the textbook due to the textbook's unique structure, density, and complex vocabulary as it differs greatly from other content area textbooks (Barton & Heidema, 2002; Idris, 2003). Many researchers have argued that special content area reading strategies are needed and that student acquisition of such strategies calls for explicit instruction by mathematics teachers (Barton & Heidema, 2002; Barton, Heidema, & Jordan, 2002; Kane, Byrne, & Hater, 1974; Porras, 1994; Shanahan & Shanahan, 2008). When a student is not successful in mathematics, teachers frequently assume the difficulty lies within the student's

mathematical ability or a negative disposition towards mathematics, but the difficulty may lie with the student's reading comprehension (Draper, Smith, Hall, & Siebert, 2005; Kane et al., 1974). In that case, incorporating content area reading strategies into classroom instruction may be a vehicle through which teachers can facilitate students' ability to learn from their mathematics textbooks (Barney, 1972; Barton et al., 2002; National Reading Panel [NRP], 2001; Ness, 2007; Searfoss & Maddox, 1986; Siebert & Draper, 2008; Smith & Kepner, 1981; Snow, 2002).

### **Background and Rationale**

In decades past, students who were poor readers could sometimes shine in mathematics given that reading was not a large part of computational mathematics (Pearce & Reynolds, 2004). Since that time literacy<sup>1</sup> has become increasingly important as society has developed from an agrarian, to an industrial, and now to an informational economy (Mid-continent Research for Education and Learning [McREL], 2001). While literacy traditionally refers to reading and writing, mathematical literacy<sup>2</sup> involves, but is not limited to, mathematical knowledge of procedures and facts, operational skills and methods, mathematical terminology, and knowledge of grammatical rules (Organisation for Economic Co-operation and Development, 2003). Simply stated, mathematical literacy is a blend of literacy and of mathematics where literacy strategies, such as

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<sup>1</sup> The definition of literacy used in this study is "the ability of an individual to read and/or write to include multiple activities (reading, writing, listening, speaking, viewing, symbolizing, etc.) with multiple associated texts (print, digital, video, symbolic, images, diagrams, graphs, conversations, etc.)" (Draper & Siebert, 2004, p. 931). Reading has always been a cornerstone of all literacy definitions.

<sup>2</sup> Mathematical literacy has also been referred to as numeracy, numerate, quantitative literacy, and quantitative reasoning but definitions for each term are not standardized in the literature.

content area reading strategies,<sup>3</sup> are tools applied by students as they read and comprehend mathematics. “The U.S. economy today demands a universally higher level of literacy achievement than at any other time in history, and it is reasonable to believe that the demand for a literate populace will increase in the future” (Snow, 2002, p. 4). In fact, by 2014, the U.S. labor force is expected to grow by 13% with 12 of the 20 fastest growing occupations requiring an associate’s degree or higher (U.S. Department of Labor, 2005). However, according to *The Nation's Report Card: 12th-Grade Reading And Mathematics 2005*, only 35% of Grade 12 students met or exceeded the Proficient<sup>4</sup> level of reading ability and only 23% of Grade 12 students met or exceeded the Proficient level of mathematical ability (Grigg, Donahue, & Dion, 2007) needed to meet the literacy demands of today and in the future.

Recently mathematics educators and teachers of mathematics have increasingly been expected to address the connection between reading skills, mathematical problem solving, and mathematics achievement (Matteson, 2006). *The Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) promotes the importance of reading and writing for K-12 students, but this call is positioned within the larger context of teachers encouraging students to develop a deep understanding of mathematics by communicating what they are thinking. Just as *The Principles and Standards* focuses on the mathematics education of K-12 students, *Beyond Crossroads* (American Mathematical Association of Two-Year Colleges [AMATYC],

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<sup>3</sup> Content area reading strategies “provide a purpose for instruction—to teach students, for example, how to activate prior knowledge, summarize and question, and organize information for recall and/or writing” (Conley, 2009, p. 532).

<sup>4</sup> The three achievement levels for the *Nation's Report Card*, from lowest to highest, are Basic, Proficient, and Advanced.

2006) focuses on the mathematics education of students at two-year colleges.<sup>5</sup> *Beyond Crossroads* promotes students' intellectual mathematical abilities, competencies, and knowledge in part by calling for students to acquire the ability to read, write, listen to, and speak mathematics, in other words, to communicate what they are thinking. Reading is clearly a tool for learning mathematics, little information is offered in the NCTM *Principles and Standards* about how to develop this tool (Draper & Siebert, 2004). *Beyond Crossroads* mirrors the NCTM *Principles and Standards*, and it too does not offer any additional information clarifying how connections between reading, communication, and mathematics should be addressed.

Both the NCTM *Principles and Standards* and the AMATYC *Beyond Crossroads* support students becoming strategic readers who are able to read, understand, and communicate information from their mathematics textbooks. However, community college teachers frequently report their students have an “inability to understand and apply information contained in their readings” (Maaka & Ward, 2000, p. 111). The field of mathematics education would benefit from knowing whether the inclusion of content area reading strategies within the instructional practices of community college-level teachers is beneficial to students' mathematical achievement. If the inclusion of content area reading strategies is beneficial, then further benefit would occur from knowing how the strategies contribute to increase student mathematical achievement.

### **Community Colleges**

Community colleges serve a unique function in the U.S. education system. Nearly all have an open-door admissions policy that allows students with a high school

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<sup>5</sup> Two-year colleges are also known as 2-year colleges, community colleges or junior colleges. The term *community colleges* will be used in this paper.

diploma or its equivalent to enroll in college, despite the student's academic background. That is to say, across the U.S., educationally at-risk students have an opportunity to pursue a post-secondary education if they so choose. Consequently, the fact that a potential student is able to enroll in college does not mean the student is academically prepared for college-level work. Community colleges have traditionally seen themselves as places for second chances and new opportunities to obtain an education. In this vein, community colleges offer extensive developmental education programs in areas such as mathematics, reading, and writing. Currently, developmental courses are offered at 99.5% of public two-year colleges and at 74% of public four-year institutions (National Center for Education Statistics [NCES], 2008). The U.S. Department of Education reports that in the fall of 2000, 42% of community college freshmen enrolled in one or more developmental courses (mathematics, reading, or writing). In particular, 35% of the freshmen enrolled in a developmental mathematics course while 20% of the freshmen were enrolled in a developmental reading course (Parsad, Lewis, & Greene, 2003). Only 43% of college-intending students who took the ACT national college admissions test in 2008 met the ACT college mathematics benchmark (ACT, 2008).<sup>6</sup> A contributing factor within these high rates of enrollment in developmental courses is the inadequate reading competency of college-intending students. Even as they enter college, the reading comprehension of some students is so limited that they are only able to understand the most basic of mathematics word problems or directions (Porrás, 1994).

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<sup>6</sup> A benchmark score is the minimum score on an ACT subject-area test predicted to indicate a 50% chance of obtaining a B or higher, or approximately 75% chance of obtaining a C or higher, in the corresponding credit-bearing college courses.

Although not addressing a community college audience directly, William B. Harvey, the executive director of the International Reading Association (IRA) recently wrote,

Reading is the centerpiece of intellectual development in any and all disciplines. While it is absolutely necessary to encourage and facilitate the increased involvement of students in the STEM [Science, Technology, Engineering, and Mathematics] field, as political leaders around the world are now doing on a regular basis, it is even more important to first assure that their literacy skills are developed to the optimum extent (Harvey, 2010, p.18).

In fact, Harvey believes STEM should be expanded to STREAM (Science, Technology, Reading, Engineering, And Mathematics) to stress the importance of reading for student success in these fields. The potential impact of limited reading ability is further evidenced when first-time community college students are required to complete both developmental reading and developmental mathematics courses: the order in which the courses are taken does make a difference. Students who completed a developmental reading course either prior to or concurrent with registration in a developmental mathematics course had higher rates of successfully completing the developmental mathematics course (Echenique, 2007). The implication for developmental students is that reading is a critical component of subsequent success in mathematics. Simply put, community colleges cannot ignore the limited reading abilities that many of their students possess.

If community college mathematics instructors are to address the issue of students' limited reading ability in their classroom, they will need professional development regarding the content area reading strategies which can be incorporated into classroom instruction. Traditionally, mathematics teachers have not been inclined to teach their students reading comprehension strategies and have not perceived much value in teaching



or using the strategies (Barney, 1972; Barton et al., 2002; Bintz, 1997, D’Arcangelo, 2002; Davis & Gerber, 1994; O’Brien, Stewart, & Moje, 1995). At the same time, many mathematics teachers compensate for the fact that their students have difficulty reading and learning from the textbook by using it mainly as a resource for homework problems (Draper, 1997; Porras, 1994). To further compensate, teachers “tell” the students all the important information about the topic which releases the students from any need to read the mathematics textbook or use it as a resource (Barton & Heidema, 2002; Draper, 1997). In addition, students find it very difficult to learn from a mathematics textbook with little or no support or direction from their teacher (Ewing, 2006). As a consequence, students do not consider reading the mathematics textbook to be their best means of learning new information, instead, they consider “hearing an explanation,” “asking someone,” and “being told what to do” as their best options (Stodolsky, Salk, & Glaessner, 1991). These students are not learning mathematics independent of their teachers nor are they learning how to construct their own meanings or make mathematical connections. Without these more advanced learning skills and strategies, students’ potential for developing long-term understanding and knowledge independently is compromised (Donovan & Bransford, 2005).

### **Developmental Education**

The term “developmental,” when applied to underprepared, post-secondary students, has been the subject of debate for several decades by scholars in the field. A number of expressions have been applied to this area of education over the years: preparatory studies, academic support programs, compensatory education, learning assistance, basic skills, and remedial education (Kozieracki, 2002). According to the

National Association for Developmental Education (NADE), developmental education consists of those education programs and services which commonly address academic preparedness, diagnostic assessment and placement, development of general and discipline-specific learning strategies, and affective barriers to learning (NADE, 2010). Students who are identified as needing to complete developmental courses often lack “the foundation and skills required for rigorous college curriculum” (Smittle, 2003, p. 10). It has been said that developmental education serves as the gateway to a postsecondary education for many students (Smittle, 2003).

More students are required to complete developmental mathematics courses than any other developmental course offered at community colleges. Furthermore, many of these same students are also required to complete a developmental reading course. In 2005, 57% of all students enrolled in mathematics courses at community colleges were enrolled in developmental mathematics courses (Lutzer, Rodi, Kirkman, & Maxwell, 2006). The most important goal of developmental mathematics programs is to help underprepared students improve their mathematics skills with the intention that they have the same possibility of graduating from college as do students who did not require any developmental courses (Penny & White, 1998).

Developmental education students are a varied group and simply share the one characteristic of being under prepared for college (Boylan, 1999). This varied population consists of traditional students who have just graduated from high school and are entering college immediately, students who completed Advanced Placement (AP) mathematics courses in high school, first-generation students, students who took time off from school before returning, career changers needing a mathematics refresher, students with

mathematics anxiety or phobias, mothers returning to school, learning disabled students, employees needing a degree to qualify for a pay raise from their company while already doing the work, students with full-time or part-time jobs, students with families, second language students, single parents, and students from all races/ethnicities and socioeconomic levels. Students enter developmental mathematics courses for a variety of reasons and with a variety of backgrounds. These are exactly the type of students for which the open-door admission policy is aimed. They are enrolling in a community college for a second chance or for new opportunities, and they are enrolling in mathematics because it is a requirement for virtually all programs of study.

Instructors of developmental mathematics are responsible for preparing mathematically deficient students to complete credit-bearing mathematics courses as subsequently required for their degree requirements. “Faculty at postsecondary institutions must recognize and embrace the importance of developing teaching skills [which includes content area reading strategies] that enhance learning for all types of students in tandem with continuing development of their content area knowledge” (Smittle, 2003, p. 14). However, it is not known how instruction in content area reading strategies will impact students’ achievement in developmental mathematics. This needs to be determined.

### **Mathematics and Reading**

Reading mathematical writing is extremely difficult due in part to the lack of redundancy in the writing system and partly to the prevailing values of professional mathematical writing. Elegance is measured in part by brevity and in part by simplicity. Accessibility plays no part. Because of structural differences between mathematical and English prose text, a different style of reading needs to be adopted by the reader, and pupils need considerable training on *how* to read mathematics. (Pimm, 1987, p. 184)

Many students enter classrooms today without the knowledge, skills, or the disposition to read, and this can impact their ability to comprehend their textbooks and other reading materials as required in schooling (Snow, 2002). Teachers contend that they are faced with students who do not have the reading or writing skills expected for the level of course work in which they are enrolled (Snow, 2002). Reading comprehension difficulties can even impact proficient readers when they are unfamiliar with the content area, style of the text, syntactic structure, vocabulary, or even the register of the content area (National Institute for Literacy, 2007). This is especially true in mathematics as mathematics textbooks are organized and styled in unique ways, as compared to textbooks addressing other subjects. In mathematics textbooks, students must read from left to right, right to left, up and down, and diagonally, while comprehending information given not only in words but also in charts, graphs, and symbols (Barton & Heidema, 2002; Franz & Hopper, 2007). The language of mathematics is a fusion of everyday language, numbers, symbols, letters, equations, graphs, diagrams, tables, and mathematical vocabulary with each carrying a profound compacting of information and a unique mathematical concept, which can be viewed as a foreign language by a student without content area reading strategies.

Reading in mathematics requires different skills/strategies from the reader than reading a novel or reading the textbooks in subjects such as history, literature, or social studies. Casual reading through a mathematics textbook is not sufficient for comprehension (Greenman, 1993). Most students have never been explicitly taught how to read and learn from a mathematics textbook. Special skills are needed and the acquisition of such skills calls for special instruction (Kane et al., 1974). Research

indicates that content area reading strategies are more effective if delivered in the classrooms where the students are expected to use the strategies to read and learn from their textbooks (Neufield, 2005). Reading in mathematics should be more than just “mining” a text for the needed information to procedurally solve problems (Pimm, 1987), it “needs to be thought of as extending beyond just gaining meaning from text to integrating that meaning into the learning process” (Meaney & Flett, 2006, p. 10). Content area reading strategies consider prior knowledge as a critical element for comprehension (Vitale & Romance, 2007).

At its most basic, teaching reading in the content areas is helping learners to make connections between what they already know and “new” information presented in the text. As students make these connections, they create meaning; they comprehend what they are reading. Teaching reading in the content areas, therefore, is not so much about teaching students basic reading skills as it is about teaching students how to use reading as a tool for thinking and learning. (Billmeyer & Barton, 1998, p. 1)

Teachers of mathematics are ideally positioned to help students better learn how to read and comprehend mathematical text; they are the experts in the content area. But to do so, mathematics teachers should be educated on content area reading strategies for mathematics. This professional development can consists of a few targeted strategies and provide information on when, why, and how to use reading strategies as well as how students may benefit from learning the strategies.

### **Statement of Purpose**

The purpose of this study is to investigate the impact of instruction incorporating content area reading strategies on student mathematics achievement in a community college prealgebra developmental mathematics course. For over 75 years, literacy educators have called for the merging of teaching content with literacy instruction, but

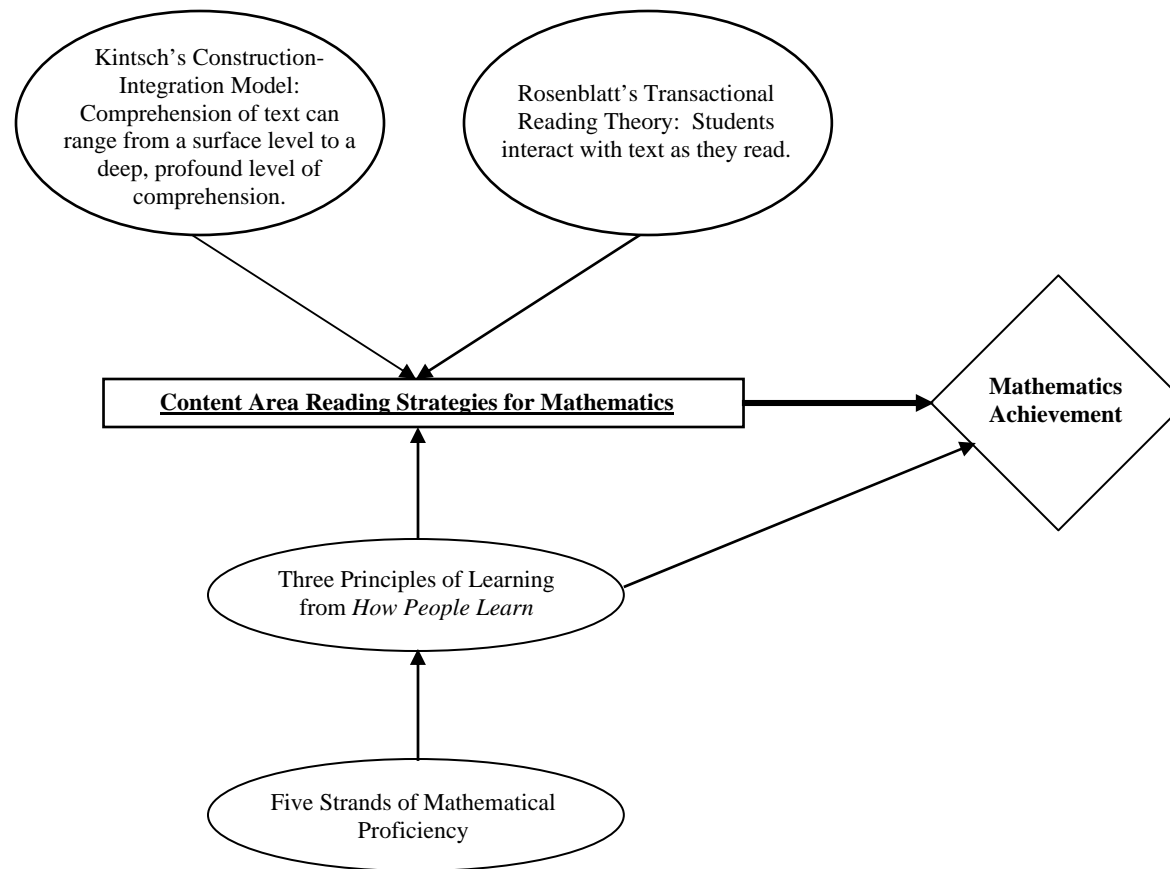
previously those recommendations were largely ignored (Draper, 2002). Reading literacy was not seen as an essential skill for students because the learning of mathematics was considered to be primarily procedural and computational. Researchers have shown that content area reading strategies can help students increase and deepen their comprehension of content area information, especially if these strategies are taught explicitly by their content area teachers (Brown, Palincsar, & Armbruster, 2004; DiGisi & Fleming, 2005; Goldman & Rakestraw, 2000; Hall, 2005; Hempenstall, 2004; Ostler, 1997; Palincsar & Brown, 1984; Pressley, 2000; Snow, 2002; Sulentic-Dowell, Beal, & Capraro, 2006; Wade & Moje, 2000). Most of these studies focused on pre-college populations, yet community colleges have adult populations in which a large number of students are required to enroll in developmental mathematics courses. It is not simply that mathematics teachers also need to be reading teachers; they should include specific content area reading strategies in their instructional practices to foster their students' ability to read and interpret the contents of mathematics textbooks (Ediger, 1997). This is especially important since college-level work requires students to assume responsibility for independent learning in mathematics by reading the textbook. In order for students to have the opportunity to construct their own meanings, to make connections from their mathematics textbook, and to become independent learners, they should be taught how to read and comprehend their textbook.

Since community colleges have high percentages of students who are required to take developmental mathematics courses, exploring the relationship between incorporation of content area reading strategies into instructional practices and the pass rate of a developmental mathematics course can clarify the potential impact of reading

strategies for developmental mathematics teachers as well as the field of mathematics education.

### **Theoretical Framework**

This study reviewed theories and research in the fields of reading and literacy, as well as mathematics education, to characterize approaches and content area reading strategies which could be incorporated into college-level, developmental mathematics courses with the goal of increasing students' mathematical proficiency through their comprehension of mathematics content from reading the course textbook. Theories that addressed increasing students' interaction with and comprehension of text were explored, and content area reading strategies were identified. The use of and design of content area reading strategies is grounded in Rosenblatt's Transactional Reading Theory, Kintsch's Construction-Integration (CI) Model of text comprehension, and the Principles of Mathematics Learning in the National Research Council publication *How Students Learn: Mathematics in the Classroom* (Donovan & Bransford, 2005). Figure 1 depicts the relationship of the three theories with this study. The bolded text represents the component examined in the study. The underlined text represents the only component offered in the treatment sections which differed from the control sections.



Bold – study only examined the bolded components in the model  
 Underline – only component in treatment sections

*Figure 1.* The figure depicts the relationship of Rosenblatt's Transactions Reading Theory, Kintsch's Construction-Integration Model, and the mapping of the five strands of mathematical proficiency onto the three principles of learning addressed in *How People Learn*, portraying how these theoretical perspectives are envisioned to support the use of content area reading strategies for impacting students' mathematics achievement.



## **Rosenblatt's Transactional Reading Theory**

Rosenblatt's Transactional Reading Theory provided theoretical grounding for the content area reading strategy choices (Borasi & Siegel, 1990; Borasi & Siegel, 2000; Borasi, Siegel, Fonzi, & Smith, 1998; Tracy & Morrow, 2006). Rosenblatt's theory suggests that the reader is actively involved with the text he or she reads; this theory discounts the perception of reading as a passive transfer of information from text to reader. The reader uses prior knowledge, past experiences, and beliefs in addition to interpreting context and purpose when reading for meaning making. The text is not static, and meaning making by the reader arises from the transaction between the reader and the text. The idea that every reader will have unique reading experiences with the same text is the foundation of Rosenblatt's Transactional Reading Theory.

In this study, several content area reading strategies were used to help support problematic areas that have consistently hampered students in community college, prealgebra developmental mathematics. The identification of these problem areas came from the teaching experiences of the researcher, the developmental mathematics course leader and the mathematics instructors at the cooperating community college, and mathematics education research literature, as well as from literacy and reading research literature. Every reading strategy was intended to focus students back to the course textbook and to provide them with reading strategies enabling them to pull information from the textbook and then to organize and comprehend that information. In other words, the students were presented with reading strategies to help them actively transact with the text of the textbook by writing, drawing, or talking with a purpose. The intention was to engage the students in meaning making.

## **Kintsch's Construction-Integration Model**

Kintsch's Construction-Integration (CI) Model of text comprehension also provided theoretical grounding for the use and design of content area reading strategies. This model differentiates between a surface comprehension (textbase) and deep, profound comprehension (situation model) of the text by the reader. "Kintsch sees strategies as important for encouraging active processing that activates any existing background knowledge" (Cromley & Azevedo, 2004, p. 7). Together, textbase and situation models of comprehension integrate students' background knowledge, also called prior knowledge, and the new textbook information into the students' long-term memory for recall as needed, both inside and outside of the mathematics classroom.

Primarily, in this study the CI model offered a view of each content area reading strategy and how the implementation could deepen the students' comprehension of the topic (e.g., discussion questions). There were 14 implementations of content area reading strategies throughout the semester. Only one implementation of a reading strategy did not include discussion questions directly associated with it. The NRP asserts that based on solid scientific research, "question answering" is 1 of 7 types of instruction shown to improve comprehension in non-impaired readers (NRP, 2001). The NRP further states that there is research supporting the effectiveness of and use of combinations of reading strategies. In this study for example, discussion questions were included as part of the reading strategy implementation. Question answering can also be used to activate prior knowledge (NRP, 2001); as it may move a student's comprehension level from a surface level of understanding to a deeper level of understanding by helping the students incorporate their prior knowledge with new knowledge.

## **Principles of Mathematics Learning**

Increasing students' mathematical proficiency at all grade levels including college is paramount. A widely accepted characterization of mathematical proficiency is that it consists of five interdependent components (Kilpatrick, Swafford, & Findell, 2001).

These components are frequently illustrated as strands of a braid which work together for the common purpose of mathematical proficiency. The five separate but dependent strands are:

- Conceptual understanding – comprehension of mathematical concepts, operations, and relations
- Procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- Strategic competence – ability to formulate, represent, and solve mathematical problems
- Adaptive reasoning – capacity for logical thought, reflection, explanation, and justification
- Productive disposition – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in the value of diligence and in one's own efficacy. (Kilpatrick, Swafford, & Findell, 2001, p. 116)

These strands are equally important, and the teaching of mathematics requires all five to be addressed in order to accomplish the goal of students becoming mathematically proficient with increased mathematics achievement. An assumption underlying this study is that when specific content area reading strategies are incorporated into classroom instruction, the resulting enhanced instruction supports all five strands of mathematical proficiency. The content area reading strategies in this study were selected to support the reading and comprehension of mathematics content in the prealgebra course textbook.

The five strands of mathematics proficiency map onto three underlying principles of learning (Donovan & Bransford, 2005):

- Principle #1: Teachers must engage students' preconceptions.
- Principle #2: Understanding requires factual knowledge and conceptual frameworks.
- Principle #3: A metacognitive approach enables student self-monitoring.

As emphasized in Principle #1, teachers must not only build on the prior knowledge students bring to the classroom, but also ensure those students' preconceptions do not interfere with learning. Many content area reading strategies are designed to bring forth students' prior knowledge on a topic and to help them blend their prior knowledge with new knowledge. In other words, Principle #1 clarifies the need to build a bridge between informal and formal knowledge. Principle #2 directly connects to the strands of conceptual understanding and procedural fluency (Fuson, Kalchman, & Bransford, 2005), essential components as students develop mathematical proficiency. This principle also points to the need for an effective organization of knowledge which facilitates another strand, adaptive reasoning. An effective organization of knowledge is vital, particularly when making the connections between mathematics concepts and procedures. Yet again, many content area reading strategies can help students organize information in a manner from which they can learn, be it the procedures, the concepts, or the connection between the two. Principle #3 emphasizes the need for students to consistently ask themselves if their computations and problem-solving approaches make sense and if their answers make sense. This metacognition or self-monitoring help students become independent learners, who can take charge of their own learning. Yet again, many content area

reading strategies have a metacognition component to them and can provide students with resources to become independent learners.

### **Research Questions**

The main focus of this study was to investigate the impact of instruction incorporating content area reading strategies on student mathematical achievement in a community college developmental mathematics course. In an effort to measure this impact, the following research questions were addressed:

Research Question 1:

What is the impact of instruction incorporating content area reading strategies on the mathematics achievement of students in a community college, prealgebra, developmental mathematics course?

Research Question 2:

What, if any, demographic factors influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?

Research Question 3:

What, if any, prior educational background of the enrolled students influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?

### **Significance**

This study may inform community colleges, developmental mathematics programs, and developmental mathematics instructors as to the value of incorporating content area reading strategies into their instructional practices. There is a vital need to

improve the success rate of developmental mathematics students at all institutions of higher education, but there is a critical need at community colleges which serve as the first entry into post-secondary education for many students. Community colleges attract a large proportion of underprepared students due to the open-door admissions policy. Many students start their college careers with the need to take developmental courses before they can take college-level courses, especially in mathematics. “Little direct attention has been devoted to helping teachers develop the skills they need to promote reading comprehension, ensure content learning through reading, and deal with the differences in comprehension skills that their students display” (Snow, 2002, p. xi). Indeed, little research has been done by the mathematics education community which specifically looks at reading comprehension strategies that can be used by students to better their comprehension when reading a mathematics textbook. This is particularly true at the secondary level and beyond in mathematics classrooms (Fisher & Frey, 2008; Franz & Hopper, 2007).

Developmental mathematics courses at community colleges are taught largely by adjunct instructors with a variety of educational backgrounds and differing levels of teaching experiences. Many content area reading strategies do not require large amounts of classroom time for teachers to implement. While theory suggests the explicit instruction of content area reading strategies can increase student mathematics achievement, whether this may be the case in community college developmental mathematics is not yet known. There is a need to determine whether the implementation of select content area reading strategies by developmental mathematics instructors, particularly adjunct instructors, can be applied and in turn yield positive mathematics

achievement for students, and as reflected in higher passing rates for the enrolled courses. This is an instructional practice which needs to be seriously considered and investigated.

### **Overall Methodology**

This study employed a quantitative control-treatment design to investigate whether the incorporation of content area reading strategies into the instructional practices of a community college developmental mathematics course was related to students' overall mathematics achievement in the course as measured by standardized course assessments and the course passing rate. The standardized course assessments consisted of uniform quizzes, course examinations, and a common cumulative final examination administered across all sections. Data collection consisted of the standardized course assessments, student demographic data provided by the college, student background information garnered from a researcher-designed questionnaire administered to the students, and additional teacher information detailing education background and educational teaching experiences as collected from a researcher-designed questionnaire completed by the instructors. Observations of both control and treatment classrooms were also conducted.

The data from the college and the questionnaires were used as descriptive data and as control variables for analyses. Specifically, student course mathematical achievement data were analyzed while controlling for student characteristics and teacher characteristics.

Approximately one-half of the course sections implemented the treatment of incorporating content area reading strategies distributed throughout the semester into the instructional practices of the course with the remaining sections identified as control

sections. The control section instructors taught in their usual manner and did not incorporate the content area reading strategies. The passing rates for the two groups of students (treatment and control) were compared to determine, in part, the impact of including content area reading strategies in the instructional practices of the treatment sections.

At the beginning of the semester, the researcher provided the treatment instructors with all materials and information needed to implement each content area reading strategy throughout the semester. Furthermore, the researcher observed treatment sections to ensure implementation of content area reading strategies. The researcher also observed control sections to ensure that content area reading strategies were not being implemented.

### **Limitations of Study**

This study has five main limitations. The first is that this study was conducted at one community college in the mid-Atlantic region with multiple campuses, limiting the generalizability of these findings to other community colleges. A second limitation is that the study was conducted during the spring semester. Fewer students enroll in this course during the spring semester than in the fall semester, and there are usually increased numbers of students repeating the course. As is typical in community colleges virtually all of the course instructors were adjunct instructors with a wide variety of educational backgrounds and different levels of teaching experience. Due to their adjunct status, these instructors also resisted additional time requirements for course preparation. These two factors led to the third limitation as the quality of implementation of the content area reading strategies varied. While scrutiny of the quality of implementation



was not part of this study, level of implementation was. A fourth limitation was that the instructors who were asked to volunteer for this study were allowed to include their choice if any, for being a treatment or control instructor, therefore introducing an element of self-selection bias. This also meant that the treatment sections of the course were not randomly assigned across locations, days, or times. Lastly, the instructors were not provided with organized professional development.

### **Definition of Terms**

Background knowledge – also known as prior knowledge, the terms are interchangeable. Both terms encompass several forms of knowledge; conceptual, metacognitive, subject matter, strategy, personal, and self-knowledge (Strangman & Hall, 2004).

Content area reading strategies - The strategies “provide a purpose for instruction—to teach students, for example, how to activate prior knowledge, summarize and question, and organize information for recall and/or writing” (Conley, 2009, p. 532).

Developmental education – Combination of programs and services designed to meet the needs of underprepared college students.

Developmental mathematics – Defined “as courses in reading, writing, or mathematics for college-level students lacking those skills necessary to perform college-level work at the level required by the institution” (Parsad et al., 2003, p. iii).

Literacy - “the ability of an individual to read and/or write to include multiple activities (reading, writing, listening, speaking, viewing, symbolizing, etc.) with multiple associated texts (print, digital, video, symbolic, images, diagrams, graphs, conversations, etc.)” (Draper & Siebert, 2004, p. 931).

Mathematical literacy - Involves, but is not limited to, mathematical knowledge of procedures and facts, operational skills and methods, mathematical terminology, and knowledge of grammatical rules (Organisation for Economic Co-operations and Development, 2003).

Mathematics text – Any mathematical information such as written explanations, mathematical symbols, solutions, tables, graphs, pictures, diagrams, examples, calculator or computer displays, notes, board work etc.

Mathematics textbook – Book that offers mathematical text but in an organized manner with chapters, headings, subheadings, text structure, vocabulary, and typographical features. Many textbooks follow an explanation-example-exercise format for each section.

Non-traditional undergraduate student – A student that exhibits one or more of the following characteristics:

- Delays enrollment (does not enter postsecondary education in the same calendar year that he or she finished high school);
- Attends part time for at least part of the academic year;
- Works full time (35 hours or more per week) while enrolled;
- Is considered financially independent for purposes of determining eligibility for financial aid;
- Is a single parent (either not married or married but separated and has dependents); or

- Does not have a high school diploma (completed high school with a GED or other high school completion certificate or did not finish high school). (Choy, 2002, pp. 2-3)

Prior knowledge – see Background knowledge.

## **Chapter 2: Literature Review**

This literature review consists of six sections. The first section covers developmental mathematics content and curriculum. It describes developmental mathematics as offered at community colleges and 4-year colleges followed by a discussion of faculty and students at community colleges. The second section discusses literacy and reading and the importance of being literate at this time in the United States. The third section moves into the connection between mathematics and literacy with more detailed discussions addressing the language of mathematics and the reading of mathematics textbooks. The fourth section explores content area reading strategies and their value as part of the instructional practice for mathematics. The fifth section covers the theoretical framework for this study which is grounded in three theories. The framework encompasses two reading theories, Rosenblatt's Transactional Reading Theory and Kintsch's Construction-Integration Model, as well as the principles of mathematics learning which discusses the mapping of the five strands of mathematical proficiency onto the three principles of learning. The final section of this chapter explains the reading strategies employed in this study and their grounding in each theory, if appropriate.

### **Developmental Mathematics Content and Curriculum**

#### **Developmental Education Courses**

Developmental education courses, for the purposes of this study, are defined "as courses in reading, writing, or mathematics for college-level students lacking those skills necessary to perform college-level work at the level required by the institution" (Parsad et al, 2003, p. iii). A review of course offerings in 2000 noted that developmental

mathematics courses were offered at nearly 100% of community colleges, while approximately 58% of 4-year colleges offered at least one developmental mathematics course (Parsad et al., 2003).

**PEQIS study.** In the fall 1995 and again in 2000, NCES conducted a national survey of postsecondary institutions, recording data within the Postsecondary Education Quick Information System (PQEIS). Analysis of these PEQIS data sets found no difference in the proportion of entering freshmen who enrolled in at least one developmental course between 1995 and 2000, but the sheer number of entering freshmen did increase (Parsad et al, 2003). In 2000, 77% of all colleges (public 4-year, private 4-year, public 2-year, and private 2-year) offered at least one developmental course in reading, writing, or mathematics. More specifically, 56% of all colleges offered courses in developmental reading while 71% offered courses in developmental mathematics. However, across both 1995 and 2000, 96% of the public community colleges offered courses in developmental reading while 97% offered courses in developmental mathematics (Parsad et al., 2003).

When viewed through the lens of enrolled students, PEQIS data (1995 and 2000) documented 22% of entering freshman at all colleges enrolled in a developmental mathematics course, exceeding the proportion of college freshmen enrolled in either developmental reading (11% in 2000) or developmental writing courses (14% in 2000) (Parsad et al., 2003). Within only public community colleges specifically, the percentage of entering freshman enrolled in developmental mathematics courses increase slightly from 32% to 35% over 1995 to 2000. In contrast, the proportion of freshmen in developmental reading and writing courses at public community colleges remained

essentially constant (reading: 19% in 1995, 20% in 2000; writing: 24% in 1995, 23% for 2000) (Parsad et al., 2003).

The average number of different developmental courses offered by all colleges did not change from 1995 to 2000. There was a constant average of 2.5 different developmental mathematics courses offered at community colleges and 4-year colleges, exceeding the average number of developmental reading courses (2.2 in 1995; 2.0 in 2000) and writing courses (2.0 in both years) (Parsad et al., 2003). Interestingly, at public community colleges, there was a decrease in the average number of different developmental mathematics courses offered from 1995 to 2000 (from 3.6 to 3.4 courses); however this was offset at private community colleges where there was an increase (from 1.3 to 1.8 courses).

The average length of time spent taking developmental courses increased from 1995 to 2000. While 67% of students at all colleges spent less than 1 year completing developmental courses in 1995, this enrollment decreased to 60% in 2000. However during that time, the number of students who spent 1 full year completing developmental courses increased from 28% to 35% (Parsad et al., 2003). The percentage of students requiring more than 1 year of developmental courses remained constant from 1995 to 2000 for any type of college. When looking specifically at public community colleges, the same pattern was found, although the proportion of students in developmental classes at community colleges was greater (Parsad et al., 2003). The larger percentage of student enrollments in developmental courses within community colleges may be due to their open door admission policy.

**NELS:88 study.** A review of the National Educational Longitudinal Study (NELS:88) dataset by Attewell, Lavin, Domina, and Levey (2006) examined college remediation (i.e., college developmental courses). Of the college students represented in NELS data, 40% enrolled in at least one developmental course during their college enrollment with mathematics being most common (28%). Unlike the PEQIS data set, the NELS:88 data set tracked students registration beyond their freshmen year. This analysis identified higher student enrollment in developmental courses at community colleges as compared to 4-year colleges, with 58% of the students enrolling in developmental courses at a community college compared with 31% at non-selective 4-year colleges (Attewell et al., 2006). These findings mirror the PEQIS findings that a larger percentage of community college students, as compared to 4-year college students, enroll in developmental courses.

In order to examine enrollment patterns from high school to college, Attewell et al. (2006) contrasted NELS:88 high school achievement scores for mathematics and reading to the students' enrollment in developmental courses at college. Sorting the students according to their scores on the high-school assessments into quartiles, they found that 10% of the students in the quartile of highest scores and 25% of students in the next highest quartile completed at least one developmental course in college.

Furthermore, Atwell et al., used transcript data collected by NELS:88 to sort the students in terms of the academic rigor and difficulty of their completed high school courses. They found that 14% of the high school seniors in the quartile identified with coursework reflecting the highest level of rigor and 32% of students in the next highest quartile completed at least one developmental course, during college. As noted by

Attewell et al. (2006), enrollment in college developmental courses was “*not* limited to NELS:88 students with low academic skills in 12th grade, or to students who have had a weak curricular preparation in high school” (p. 899).

Looking specifically at the relationship between completing two or more developmental mathematics courses and graduation rates from 4-year colleges Attewell et al. (2006) found that completing these courses had no effect on graduation rates. This study approached the statistical analysis differently from previous similar studies by controlling for students’ academic skills prior to entering college (e.g., skills test in senior year and high school transcripts) and allowed 8.5 years for graduation. These findings therefore do differ from the prevailing wisdom that if students are required to complete developmental mathematics courses, then their probability of graduating is significantly reduced.

When the same analytic lens was applied to community college enrollment data, the findings differed slightly. Community college students who completed two or more developmental mathematics courses had a statistically significant 3% lower probability of graduating with a degree. At the same time, this investigation noted that completion of developmental courses for reading and or writing improved the probability of graduation. Furthermore, when community college students enrolled in developmental courses, 68% passed writing, 71% passed reading, but only 30% passed mathematics. Attewell et al. (2006) concluded that many students in developmental mathematics courses required more than one attempt prior to passing and this could be influencing students to drop out of college. However, there was no difference in the graduation rate between community college students who completed at least one developmental mathematics course and those



who were never required to enroll in a developmental mathematics course. This indicates that completing developmental mathematics courses can be beneficial to community college students, while this was not the case for 4-year college students.

### **Developmental Mathematics Content and Courses**

Developmental education courses have been defined “as courses in reading, writing, or mathematics for college-level students lacking those skills necessary to perform college-level work at the level required by the institution” (Parsad et al., 2003, p. iii). Therefore, it would seem reasonable that a developmental mathematics course would be any mathematics course which does not reach the level of college-level work.

However, there is not a clear definition for college-level mathematics. In fact, colleges assign the designation of “developmental” to mathematics courses according to their own standards. Yet, typically colleges consider the sequence of courses from basic arithmetic up to and including intermediate algebra to be developmental (Chang, 1983; Stigler, Givvin, & Thompson, 2010). By this standard, college algebra would be the lowest-level college mathematics course.

A comprehensive study was conducted to compile a listing of those prerequisite mathematics skills and understandings necessary for success in an entry-level, college mathematics course (Conley & Bodone, 2002). This list was not organized in terms of the required mathematics courses or course content, rather is it categorized by topic: computation (basic arithmetic), algebra, trigonometry, geometry, mathematical reasoning, and statistics. Each of these content categories is further detailed as to what a student should understand or be able to do specific to that mathematical topic. Since the developmental mathematics designation applies mainly to algebra, the prerequisite

mathematical skills of interest are those expected prior to entering a college-level algebra course. That is, the skills and understandings students would be expected to learn in developmental mathematics courses. These include:

- The student will know and apply basic concepts;
- The student will use various techniques to solve basic equations and inequalities;
- The student will be able to recognize and use basic algebraic forms;
- The student will understand the relationship between equations and graphs;
- The student will know how to use algebra both procedurally and conceptually; and
- The student will demonstrate ability to algebraically work with formulas and symbols. (Conley & Bodone, 2002, pp. 11-12)

Student placement into a developmental mathematics course is usually determined via one of three ways: attained a minimum mathematics placement test score, completed prerequisite course(s), or elected to take the most basic mathematics course available. The most common mathematics placement tests administered by colleges are Accuplacer and COMPASS, although many colleges develop their own mathematics placement tests in-house. Older, returning students will often opt to register for the most basic mathematics course due to anxiety associated with completing a mathematics placement test.

Developmental mathematics courses are offered in many formats: the traditional face-to-face classroom format which meets usually 2-3 times per week, the web-hybrid format where a portion of the course is online but also meets once a week in face-to-face

sessions, the computer lab format where students attend classroom sessions as in a traditional format but during class only work individually on a computer at their own pace, and the online format. Colleges will offer courses with multiple sections each assigned to a single format, thereby allowing a single course to be offered through a variety of formats. Virtually all formats of these courses have a computer component, even the traditional face-to-face format. In that case, expected use of computer software offers supplemental tutoring and practice.

Developmental courses, including developmental mathematics courses, may or may not earn a student college credit when determining workload, however, those credits will not satisfy requirements for completion of a degree, even as elective credits. However, the additional credits earned from completing developmental courses do satisfy expectations for workload and full-time/part-time student status within financial aid or student grants requirements.

### **Community College Students and Faculty**

Community colleges operate in every state in the nation as open admission institutions accepting virtually any student who applies and can pay the tuition. This policy invites students of every description and ability who are interested in broadening their opportunities, an admirable goal. Community colleges are aptly named as they are integral to and serve the communities in which they are located. Often the colleges work with the business community to ensure that opportunities are available for the local population to obtain the skills needed for employment with local businesses (Parsad et al., 2003). The skills offered can be vocational and academic. Furthermore, often community colleges receive part of their funding from the county (or parish) and state in

which they reside, as well as from student tuition. Therefore, the financial health of a community college is tied to the financial health of its community.

**Students.** Since community colleges are part of the local community, a very large majority of their student population typically comes from the local community. It is interesting that approximately 15% of community college students are international students (Redden, 2007). These students find the costs associated with English as a Second Language (ESL) courses to be less expensive at a community college as contrasted to private or 4-year institutions.

In 2007, approximately 18.2 million students attended either a community college or a 4-year college (Hussar & Bailey, 2009). Of this number, 6.6 million (36%) attended a community college. A comparison of the percentages of full-time and part-time students at these two types of institutions reveals a striking difference. Across all colleges, 62% of the students attend college full-time, however only 41% of community college students attended full-time.

Non-White and non-Asian students compose larger percentages of community colleges' student population than at 4-year colleges (Hussar & Bailey, 2009). Asian students attend both types of colleges equally, reflecting 5% of the student population. White students compose 60% of the community college student population but 69% of the 4-year college student population. In contrast, African American students compose 15% of the community college student population and only 11% at 4-year college populations. Hispanics compose 14% of the community college student population but only 10% of the 4-year college student population. This level of student diversity

speaks to the service that community colleges offer and their open door policy, offering an opportunity for all to seek education (Hussar & Bailey, 2009).

Community colleges are appealing to many people for many reasons. This is particularly noticeable by the age of the students who attend. Approximately one-half (47%) of the registered students are 23 years old or younger, while students in this age group compose 70% of the student population at 4-year colleges. Students who are 24 to 29 years old compose 18% of the community college population; while a slightly lower proportion (14.5%) are enrolled at 4-year colleges. Finally, over twice as many students 30 years and older attend community colleges (35%) as compared to 4-year colleges (16%) (Horn & Nevill, 2006). This seems to be indicative of the community college mission to offer opportunity for any student to obtain an education if desired.

**Faculty.** As of 2003, two-thirds of the faculty at public community colleges were adjunct faculty (Cataldi, Fahimi, & Bradburn, 2005). This is the highest percentage of adjunct faculty for any type of postsecondary institution. The number of male and female faculty are evenly divided for both full-time and adjunct faculty with almost 340,000 members employed by community colleges. However, female faculty represented only 37% of the full-time faculty at public 4-year colleges (Cataldi et al., 2005). Thus, while community college faculty members are more likely to be adjuncts, these faculty members are evenly distributed by gender. The distributions of faculty members by race are approximately the same for 4-year and community colleges (Cataldi et al., 2005).

Comparisons of the highest degree obtained show a marked difference between faculty at 4-year colleges and community colleges (Levesque, Laird, Hensley, Choy,

Cataldi, & Hudson, 2008). Expectedly so, faculty at 4-year colleges have over 4 times more doctorate/professional degrees, with 67% at 4-year colleges and 15% at community colleges. This is understandable as community colleges are not research institutions and focus predominantly on teaching. Community college faculty are twice as likely to have a Master's degree (52%) as their highest degree than faculty at 4-year colleges (27%). Similarly, community college faculty are three times more likely to hold a Bachelor's degree as the highest degree obtained (18%) as compared to faculty at 4-year colleges (5%).

### **Literacy and Reading**

The simplest and most commonly recited definition of being literate is having the ability to read and write. In today's world the definition of literacy has unavoidably grown, due in part to the changing workplace and the expansion of information-based technology (Shanahan & Shanahan, 2008). A more recent and more encompassing definition of literacy is, "the ability of an individual to read and/or write to include multiple activities (reading, writing, listening, speaking, viewing, symbolizing, etc.) with multiple associated texts (print, digital, video, symbolic, images, diagrams, graphs, conversations, etc.)" (Draper & Siebert, 2004, p. 931). However, for any definition of literacy, reading has always been a significant part. Gradually more and more jobs require and depend upon reading. "A generation ago, jobs in factories, foundries, and mills commonly required no reading, and many other jobs (e.g., law enforcement, practical nursing, trucking) required reading in limited amounts, but this has changed" (Shanahan & Shanahan, 2008, p. 41). As the knowledge and use of technology has expanded, many blue-collar jobs are disappearing and other jobs such as nursing are

expanding, with many specialties calling for higher levels of literacy. Shanahan and Shanahan also pointed out that an individual's level of literacy plays a large roll in maintaining health, achieving academic success, avoiding imprisonment, keeping informed on public issues, and voting. It is important to note that not only is literacy directly associated with academic success but it is also associated with income levels and employment opportunities. In other words, generally speaking, the more education obtained, the more income earned.

The field of reading is comprised of five main areas of study: phonemic awareness, phonics, fluency, vocabulary, and comprehension (NRP, 2001). Together, these five areas describe how a person becomes a reader. Learning to read is a paradox. Adults who are good readers see reading as a natural and simple activity that is easily learned by children. Yet the truth is that learning to read is “an extraordinarily effortful task, a long and complicated process that can last for years” (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001, p. 31).

A simplistic explanation of the process of learning to read begins with children matching sounds with letters or parts of words (phonemic awareness), then they learn to blend the sounds to make words (phonics). These first two areas are also known as “decoding” which is when students decode the squiggles on a page into a word or sentence. Once they can recognize and pronounce words, they practice reading with inflection and with some speed (fluency). Next, they learn word meanings (vocabulary) and become able to identify contractions, abbreviations, synonyms, antonyms, and so forth. Last, they learn to comprehend the text they are reading. Comprehension is

viewed as the “essence of reading” (Durkin, 1993); it is essential for both academic and lifelong learning.

Students learn how to read while in elementary school where reading instruction “is primarily based on descriptive narrative material rather than expository material” (Porras, 1994, p. 9). While narrative text is the primary text form from which students learn to read, students are eventually expected to apply those learned skills to expository text, such as that presented in mathematics textbooks, with little instruction. It is commonly held that in early elementary school, students “learn to read” and from upper elementary school and beyond, students “read to learn.” This implies that everything a student needs to know in order to read has been learned by the time they enter high school.

In high school and beyond, the text students are expected to comprehend contains more complex information as well as information addressing previously unknown content areas. The skills older students have learned thus far are basic and are commonly viewed to be “widely adaptable and applicable to all kinds of texts and reading situations” (Shanahan & Shanahan, 2008, p. 40). The idea has been that with practice, a student’s basic reading skills would evolve into more advanced reading skills (e.g., moving from narrative to expository text reading), yielding the ability to read for information. This is partially true when focusing on “decoding” skills and some basic vocabulary knowledge. However, as students progress through school and encounter different content areas and the topics therein, they need more instruction on vocabulary and comprehension strategies.



Research has shown that third-grade students who read at grade level “will not automatically become proficient comprehenders” (Snow, 2002, p. xii) and that teachers must explicitly teach comprehension at all levels of schooling. “Learning to read well is a long-term developmental process” (Snow, 2002, p. xiii). Even proficient readers will have difficulty when they encounter new words, read text introducing new topics and concepts (e.g., mathematics text), and interpret text within unfamiliar formats such as those found in information-based technologies. “Students have difficulty comprehending their science, math, and social science texts because of their difficulties with vocabulary, text structure, comprehension, and so on” (Shanahan, 2009, p. 241).

### **Mathematics and Reading**

This study drew on research from the fields of mathematics education and reading education to characterize a combined research perspective examining impact on student achievement in mathematics. The field of mathematics education is concerned with developing students’ mathematical thinking and understanding. The field of reading is concerned with teaching readers to derive meaning from text. The common thread is that both fields, at the core, have a common goal: for students to connect with the information presented in text, to comprehend and learn the information in a deep, profound way, and to be able to connect and apply the information in new settings or with prior knowledge.

Virtually all mathematics courses require students to use a textbook, although it is widely accepted that students are generally not adept at using the mathematics textbook for much more than a repository for examples and homework problems. Textbooks should be an important part of the teaching and learning that occurs in mathematics classrooms. To bring mathematics textbooks into the fold of teaching and learning with

students and instructors will require that the uniqueness of the language of mathematics in the textbooks be viewed from a reading perspective for the purpose of deriving meaning of the mathematics.

### **The Language of Mathematics**

The language of mathematics is a fusion of everyday language, numbers, symbols, letters, equations, graphs, diagrams, mathematical vocabulary, and specialized phrases, such as “if and only if, if...then, A or B, A and B.” Examples of specialized symbols and notation which appear in various mathematics textbooks are shown in Figure 2.

$$\pi, \quad \Delta, \quad \sum_{i=1}^{10} x_i, \quad \pm, \quad x^2, \quad \sqrt[3]{y}, \quad \infty, \\ \log_5 p, \quad f(x), \quad (f \circ g)(x), \quad \bar{x}, \quad \hat{p}$$

*Figure 2.* Examples of symbols and notations from several areas in mathematics.

Though the mathematics of a prealgebra textbook is considered lower-level mathematics, there are still numerous symbols and notations that students must understand, such as those shown in Figure 3.

Figure 3

$$\begin{array}{l} \frac{a}{0}, \quad a^n, \quad a^0 = 1, \quad kx^n, \quad \frac{-a}{b} = -\frac{a}{b} = \frac{a}{-b}, \quad |x|, \quad (x, y), \\ ax + b = c \text{ where } a \neq 0, \quad \frac{a}{b} = a : b = a \text{ to } b, \quad (\sqrt{b})^2 = b, \\ a < x < b, \quad x \geq a, \quad a^{-n} = \frac{1}{a^n}, \quad a^m a^n = a^{m+n}, \quad (a^m)^n = a^{mn} \end{array}$$

Figure 3. Examples of symbols and notations in prealgebra mathematics textbooks.

Each of these symbols represents a profound compacting of information and a unique mathematical concept, which can be viewed as a foreign language by a student without exposure to content area reading strategies. For each symbol, a student must understand the inherent rules associated with the symbol. For example, why does the mathematical statement  $ax + b = c$  in Figure 2 require *where*  $a \neq 0$ ? Even punctuation in mathematics textbooks can have different uses from the normal usage in literature (Barney, 1972). For example, the colon is used to represent ratios in mathematics as shown in Figure 2; however in literature it is used to introduce the text that follows or to add emphasis.

In addition to symbols and notations, it is essential that students be aware of mathematics vocabulary (Rubenstein, 2007). Mathematics vocabulary includes words from everyday language and words that are used strictly in mathematics. Table 1 shows categories of challenging algebra vocabulary with examples (Rubenstein, 2007). Each category has the potential to cause student confusion. The vocabulary words in Table 1 each represent a compacting of information and a unique mathematical concept, not unlike that imparted by symbols and notations. The vocabulary word *variable* is listed in

the first category of Table 1 as a shared word between everyday language and mathematics. In everyday language usage, variable is defined as something that is apt to change or vary, to be changeable or inconstant. However, in the developmental prealgebra course textbook in this study, variable is defined as a symbol, usually a letter of the alphabet, used to represent an unknown number (Wright, 2008). The common thread between the two definitions is that of change. Given that the idea of variable is a key concept in mathematics, students must apply the correct definition, or they will have difficulty comprehending the mathematics. Another example is from the second category of Table 1, of words that are shared with other content areas. The vocabulary word *power* has several definitions apart from mathematics. In the same course textbook, power is not so much defined as it is used as a label. “In the equation  $3^5 = 243$ , the number 243 is the **power**, 3 is the **base**, and 5 is the **exponent**” (Wright, 2008, p. 79). Bolded words in a textbook typically indicate new vocabulary words. Other content area definitions for power are: ability to do something (e.g., business), vigor, force and strength (e.g., physical fitness), influence, authority, and legal authority (e.g., politics), physical force or energy (e.g., electricity), and the degree of magnification of a lens (e.g., photography). Instructors should be aware of the possible definitions which students could be incorrectly applying to mathematics vocabulary.

Table 1

*Categories of Algebra Vocabulary Challenges*

Category of Challenge	Vocabulary Samples in Algebra
Some words are shared with everyday language, sometimes with distinct meanings, sometimes with more technical meanings.	Variable Function Origin Relation
Some words are shared with science or other content areas.	Power Degree Vertex
Some words are only found in mathematics.	Integer Polynomial
Some words have multiple meanings.	Square Cube Range Tangent
Some words are learned in pairs that often confuse students.	Domain and range Horizontal and vertical Associative and commutative Solve and simplify
Some words sound like others (homonyms and near homonyms).	Intercept, intersect Pi, pie

*Note.* Table 1 is a modified version of Table 1 from Rubenstein (2007), p. 202.

Students use the language of mathematics in order to communicate their ideas clearly. When reading or writing, students should understand the mathematical symbols and notations as well as the vocabulary. Mathematics is very terse in the way information is conveyed. Students who are struggling readers can find the symbols, notations, and vocabulary of mathematics especially difficult to comprehend. Solving mathematics word problems requires the ability to translate the language of English into the language of mathematics. Reading directions for mathematical problems requires a

student to understand the difference between vocabulary words such as *solve* and *simplify* or between *evaluate* and *estimate*.

Recent studies have shown that when the language of mathematics text and mathematical problems is modified, it is easier for students to understand. A modified language version maintains the same mathematical tasks as the original language version. A study addressing modified language indicated that by simplifying the language of mathematical test items, students improved their performance on assessments, with the largest improvement occurring for students in lower-level mathematics classes (Abedi & Lord, 2001). Another study, Reading to Learn Mathematics for Critical Thinking (RLM) (Borasi & Siegel, 2000), looked at the effects of a few content area reading strategies on student understanding. However, mathematics textbooks were not used. Students were introduced to “math-rich texts” and content area reading strategies to better comprehend the mathematics and make connections. The math-rich texts were similar to trade books with the mathematical language modified. That is, the language was less technical than typically presented in a mathematics textbook, and this too helped the students better comprehend the texts they were reading. Both studies point to the advantage of modifying the language of mathematics to help students learn more from reading. This can be accomplished by rewriting mathematics test items and by teaching students how to modify their own access to the mathematics textbooks by restating or rewording the text they are reading.

### **Mathematics Textbooks**

Mathematics textbooks “are an intricate part of what is involved in doing school mathematics; they provide frameworks for what is taught, how it might be taught, and the

sequence for how it could be taught” (Nicol & Crespo, 2006, p. 331). They are also the central resource in many mathematics classrooms for teaching and learning (Ewing, 2006).

Mathematics textbooks are not organized like textbooks in other content areas. Students must read from left to right, right to left, up and down, diagonally, and comprehend information given in forms other than words, forms such as charts, graphs, and symbols (Franz and Hopper, 2007). Most sections in a mathematics textbook follow a general organization of a repeated cycle of *exposition – examples – exercises* (Love & Pimm, 1996). Authors of textbooks use text features such as different font sizes, colors, boxes or shading, to signify what is considered important. Yet, students seldom give attention to more than the examples and exercises, ignoring the exposition and the text features.

Textbooks are intimidating and confusing to students. Students may avoid reading their mathematics textbooks for two different reasons (Draper, 1997, p. 33).

1. Mathematics textbooks are highly technical. They contain little or no extraneous information and each word is important and has been carefully selected by the author(s) for its precise meaning. All the words must be read and understood for comprehension.
2. No one has required students to learn from their mathematics textbooks. Students have not been taught how to read the textbook therefore, teachers do not let textbooks be the primary source of mathematical information in the classroom.

Many secondary mathematics teachers compensate for the fact that their students have difficulty reading and learning from the textbook by using it mainly as a resource for homework problems (Draper, 1997; Porras, 1994). To further compensate, teachers “tell” students all the important information about the topic which releases the students from any need to read the textbook or to use it as a resource for mathematics information

(Barton & Heidema, 2002; Draper, 1997). In addition, students find it very difficult to learn from a mathematics textbook with little or no support or direction from their teacher (Ewing, 2006).

In order for students to have the opportunity to construct their own meanings, to make connections from their mathematics textbooks, and to become independent learners, they should be taught how to read and comprehend their textbook. The logical interpretation is that students who are taught content area reading strategies for mathematics are likely to develop self-efficacy and control belief (Pintrich, Marx, & Boyle, 1993) characteristics that are essential for independent learners. In 1989, Pintrich “found that internal control beliefs were positively related to college students' use of deep processing and metacognitive strategies and their actual performance on class exams, lab reports, and papers, as well as in [the] final grade in the course” (as cited in Pintrich, Marx, & Boyle, 1993, p. 188). They maintain that an “increase in control beliefs could lead to deeper levels of cognitive engagement” (Pintrich, Marx, & Boyle, 1993, p. 190).

Moreover, by learning content area reading strategies students can integrate the language of mathematics and mathematical skills to become independent problem solvers (Idris, 2003). Independent learners believe they have control over their learning and will actively seek understanding for themselves without necessarily expecting the teacher to do so for them. There are many reasons why educators believe that it would be advantageous for students to be taught and encouraged to read the mathematics textbook (DeLong & Winter, 2002, pp. 56-57). These include:

- Reading is a better vehicle for promoting retention, as compared to lecture;
- Using multiple approaches to teach the material can accommodate different learning styles;



- There is limited amount of class time to “cover material” in appropriate depth, necessitating expectations for self-directed learning by reading text;
- An introduction to the basic vocabulary and skills can easily be acquired by reading the textbook, thereby leaving class time for clarification, extension, and reinforcement of the material;
- Access to more than one narrative on the material, the instructor’s and the author’s, can provide for a broader and more robust understanding of the material;
- The graphics and figures interspersed within the text facilitate connection among graphical, numerical, symbolic, and verbal representations; and
- Reading technical material is a valuable transferable skill for future employment and for life-long learning.

### **Content Area Reading Strategies**

The RAND Reading Study Group defines *reading comprehension* “as the process of simultaneously extracting and constructing meaning through interaction and involvement with written language. It consists of three elements: the reader, the text, and the activity or purpose for reading” (Snow, 2002, p. xiii). The reader does the comprehending, the text is what is to be comprehended, and the activity provides a purpose for the reading. Within this study, the reader is a student in a developmental prealgebra mathematics course, the text is predominately the mathematics course textbook where the written language is far more involved than straight prose, and the activity is to utilize one or more content area reading strategies in order to comprehend the textbook and its content. These reading strategies are intended to guide the interaction between reader and text enabling the reader to make sense of the information read.

Numerous researchers have shown over and over again that content area reading strategies can help students increase and deepen their comprehension of content area

information, especially if these strategies are taught explicitly by their content area teachers (Brown et al., 2004; DiGisi & Fleming, 2005; Donahue, 2003; Duffy, Roehler, Sivan, Rackliffe, Book, Meloth, Vavrus, Wesselman, Putnam, & Bassiri, 1987; Goldman & Rakestraw, 2000; Hall, 2005; Hempenstall, 2004; Ostler, 1997; Palincsar & Brown, 1984; Pressley, 2000; Snow, 2002; Sulentic-Dowell et al., 2006; Wade & Moje, 2000; Williams, 2008). When reading strategies are made explicit, students do not need to guess the purpose of the strategy, how to apply it, or the expectations. The instructor and student alike are working together for a common goal.

Content area reading strategies, as defined in this study, “provide a purpose for instruction—to teach students, for example, how to activate prior knowledge, summarize and question, and organize information for recall and/or writing” (Conley, 2009, p. 532). Readers who are actively reading to derive meaning from the text must activate their prior knowledge. NRP (2001) recognized that the reviewed studies of effective and promising reading strategies showed significant effects on how students activated prior knowledge. Furthermore, by activating students’ prior knowledge, the students’ perspective on the new information and the amount of attention that they give to it will be affected (Alexander & Jetton, 2000). By using prior knowledge to make sense of the new information, students retain the new information better in memory and continually updated it as more prior knowledge is used to inform more new information (NRP, 2001). Activation of prior knowledge is a critical element of learning. In other words, comprehension moves from a surface-level to a deeper, more profound level with the activation of prior knowledge.

When students are taught content area reading strategies they show better recall when tested at later dates. Fifth-graders who were taught reading strategies for 4 days were shown to have better recall of information for factual short answers 2 weeks later when compared to peers who were not taught the strategies or who worked independently but received frequent feedback from the teacher (Adams, Carnine, & Gersten, 1982). A similar study with high school students showed that students who were taught reading strategies were better able to read and comprehend new reading passages one month later when compared to their peers who were not taught the strategies (Goldman & Rakestraw, 2000).

A landmark study of seventh-graders, with 65% of the students categorized as poor readers, showed that reciprocal teaching (defined as including the four activities of summarizing, questioning, clarifying, and predicting) demonstrated significant improvement in student comprehension and the effect was durable (Palinscar & Brown, 1984). It is notable that after teachers were trained in the implementation of reciprocal teaching and used it for the duration of the study they became enthusiastic due to the obvious student comprehension improvements and said they would continue to use reciprocal teaching. The teachers were not enthusiastic at the beginning of the study, and therefore their change in attitude was a surprising positive result. Reciprocal teaching forced the students to become active readers.

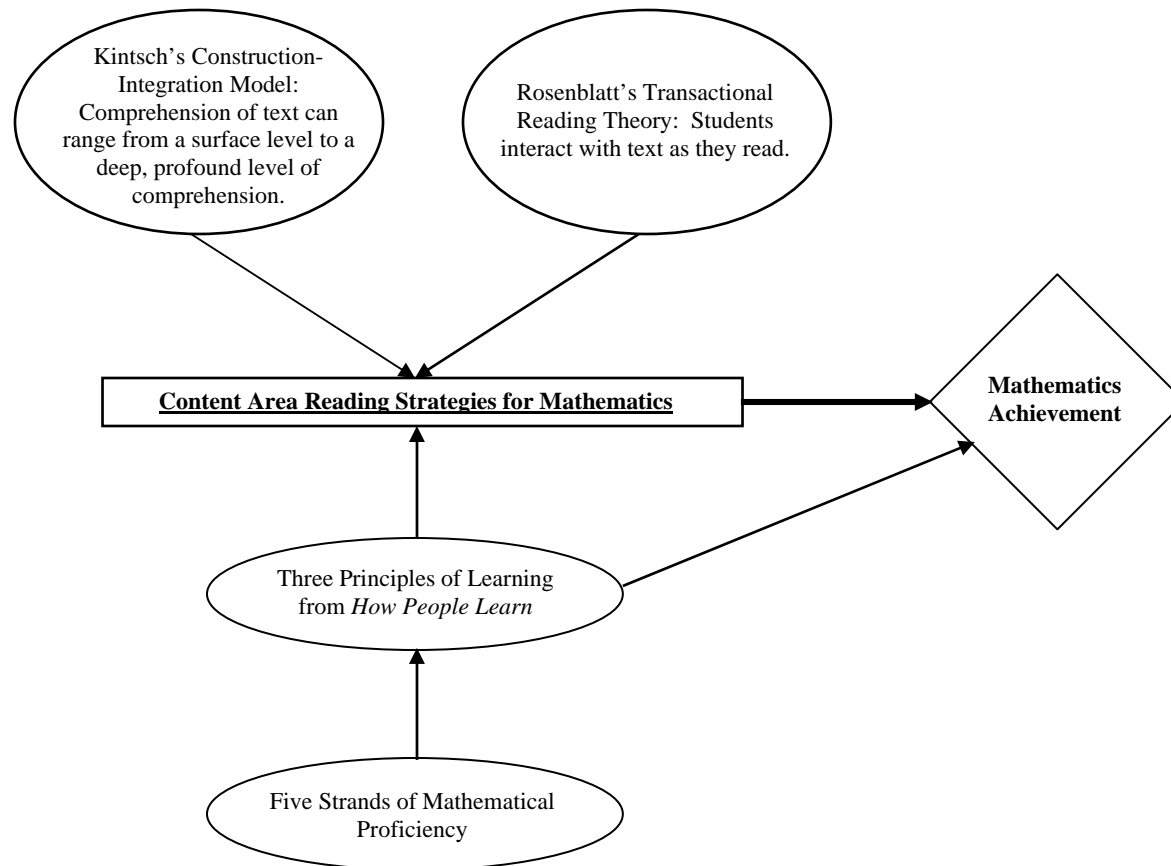
It is known that passive reading is not consistent with adequate comprehension and that when teachers model their own active comprehension processes for their students, and provide encouragement, guidance, and regular practice opportunities, students make superior progress than when teachers assume that such processes develop naturally. (Hempenstall 2004, p. 743)

## **Theoretical Framework**

As briefly covered in Chapter 1, this study reviewed theories and research in the fields of reading and literacy, as well as mathematics education, to characterize approaches and content area reading strategies which could be incorporated into college-level, developmental, mathematics courses with the goal of increasing students' mathematical proficiency through their comprehension of mathematics content from reading the course textbook. "Comprehension of text in any domain is a dynamic transaction that requires decoding the language, activating appropriate schemas or world knowledge to support comprehension, and filtering incoming information through existing knowledge structures" (Pape, 2004, p. 208). For this study, reading strategies were designed to encourage students' interaction with the course textbook. The theoretical framework for this study benefited from the intersection of three theories. In particular, Rosenblatt's Transactional Reading Theory addressed the importance of supporting students' efforts to interact with the course textbook. Kintsch's Construction-Integration (CI) Model of text comprehension was used to deepen the level of student comprehension due to the incorporation of the content area reading strategies into the course. Whereas Rosenblatt's Transactional Reading Theory pictures the reader transacting with the text, Kintsch's CI model focuses attention on the knowledge that readers construct as the result of the transaction.

Further theoretical grounding comes from the work of Fuson et al. (2005) in which the five intertwining strands of mathematical proficiency were directly mapped onto the three principles of learning (Donovan & Bransford, 2005). Mathematics instructional practices should strive to encourage students' mathematical proficiency and

therefore the three principles of learning. Content area reading strategies can be complementary to these ideal instructional practices. Figure 1 depicts how the researcher envisions the three theories working together to support the use of content area reading strategies in impacting students' mathematics achievement. The bolded text represents the component examined in the study. The underlined text represents the only component offered in the treatment sections which differed from the control sections.



Bold – study only examined the bolded components in the model  
 Underline – only component in treatment sections

*Figure 1.* The figure depicts the relationship of Rosenblatt's Transactions Reading Theory, Kintsch's Construction-Integration Model, and the mapping of the five strands of mathematical proficiency onto the three principles of learning addressed in *How People Learn*, portraying how these theoretical perspectives are envisioned to support the use of content area reading strategies for impacting students' mathematics achievement.

## **Rosenblatt's Transactional Reading Theory**

Louise M. Rosenblatt published the first of her two seminal books in 1938. In her first book titled *Literature as Exploration*, the idea that readers transact with the text was introduced. This differed from the prevailing idea of the day where the reader only needed to find “the ‘correct’ meaning *in* the text” (Damico, Campano, & Harste, 2009, p. 178). Her second book titled *The Reader, the Text, the Poem: The Transactional Theory of the Literary Work*, published in 1978, contained the fullest presentation of her theory (Rosenblatt, 2004). Rosenblatt's Transactional Reading Theory provided theoretical grounding for the use of content area reading strategies for this study (Borasi & Siegel, 1990; Borasi & Siegel, 2000; Borasi et al., 1998; Graves & Liang, 2008; Rosenblatt, 2004; Tracy & Morrow, 2006). By actively transacting with the text, readers are doing more than reconstructing what the author intended (Borasi et al., 1998). This theory can be applied to all modes of reading. The cornerstone of the theory is that every reader has a different experience when reading (Tracey & Morrow, 2006). These differing experiences, for example, are due to the purpose for the reading, the reader's linguistic and life experiences and interests, the reader's feelings and past experiences with text, and the reader's prior knowledge. Students make meaning when transacting with the text, the meaning does not lie in the reader or in the text, but in the transaction of the two (Rosenblatt, 2004). Consequently, readers have an essential responsibility in the construction of meaning.

Rosenblatt's theory discusses the stance of a reader when engaged in reading. A reader takes a stance based on the purpose for reading a selected text. Rosenblatt notes that efferent and aesthetic stances are two ways of looking at the world, namely, scientific

and artistic (Rosenblatt, 2004). An aesthetic stance is one in which a reader “pays attention to—savors—the qualities of the feelings, ideas, situations, scenes, personalities, and emotions that are called forth and participates in the tensions, conflicts, and resolutions of the images, ideas, and scenes as they unfold” (Rosenblatt, 2004, p. 1373). Usually, text such as a story, play, or poem is the type of text for which a reader will take a predominantly aesthetic stance when reading. Essentially, the reader desires to *experience* the text as it is read. An efferent stance is described to be when readers give attention to “what is to be extracted and retained after the reading event” (Rosenblatt, 2004, p. 1372). Texts which could normally evoke an efferent stance, for example, would be a newspaper, textbook, or medical report. “Meaning results from abstracting out and analytically structuring the ideas, information, directions, or conclusions to be retained, used, or acted on after the reading event” (Rosenblatt, 2004, p. 1373). For instance, for a student to engage in a predominantly efferent stance when reading a mathematics textbook, more effort would be warranted from that student than if reading from a predominantly aesthetic stance.

Virtually every text is a combination of efferent and aesthetic stances, but emphasis will vary from text to text and reader to reader and therefore a stance is considered to be on an efferent-aesthetic continuum. Rosenblatt is insistent that a text is not solely efferent or aesthetic, although it may be *predominantly* one or the other but that “does not rule out fluctuations” along the continuum (Rosenblatt, 2004, p. 1375). A textbook may well be read with a predominantly efferent stance; however an example or illustration within the textbook may evoke an aesthetic stance for that moment.



Different readers can approach the same text from different points on the efferent-aesthetic continuum; it depends on the purpose for the reading. Rosenblatt points out that an experienced reader usually draws on the cues in a text such as headings, titles, or margins to help determine which predominant stance to apply (Rosenblatt, 2004). Moreover, instructors can greatly influence the predominant stance students may take when reading assigned text. The efferent stance is the stance which students in a developmental mathematics course may predominantly hold when asked to read the textbook. As previously mentioned, to take an efferent stance when reading a mathematics textbook, more effort will be required from the student to “extract and retain” needed information.

Every content area reading strategy designed for this study had the intended purpose of the students being able to comprehend, learn, and take-away new information from the textbook. The use of the reading strategies not only aided students with transacting with the textbook, but provided a purpose for that transaction. In this study, activation of prior knowledge was actively sought by the use of the content area reading strategies with the ultimate intended purpose of students extracting and retaining new mathematical information. A study conducted with college students indicated that students who can transact with text, in the way Rosenblatt theorized, are highly engaged readers; the better a student can transact with the text, the deeper their understanding (Schraw & Bruning, 1999).

### **Kintsch’s Construction-Integration Model**

Kintsch’s CI Model is based upon a proposal by Walter Kintsch from 1978. The model has gone through several iterations with the help of Kintsch and other researchers

and continues today to be expanded upon and refined. The CI model is a contemporary, flexible, interactive model that is widely cited in reading research; it is built “on a wide range of prior psychology and reading research” (Cromley & Azevedo, 2004, p. 4). This model has also been used in several empirical studies wherein other researchers have extended and modified the model, including applications for reading in mathematics. It is notable that Kintsch’s CI model is “the only comprehension model specifically named in the National Reading Panel (2001) report” (Caccamise & Synder, 2005, p. 6).

Kintsch’s CI model of text comprehension is a connectionist theory (Cromley & Azevedo, 2004; Sanjose, Vidal-Abarca, & Padilla, 2006). This model spotlights reading comprehension of text developed with psychology research on knowledge activation (Nassaji, 2007). The model describes the complete reading comprehension process beginning with the reader decoding words to constructing meaning from text. “Text comprehension, from the perspective of the CI model, is highly interactive. Processes at many different levels interact—the perceptual processes involved in reading or listening, syntactic and semantic analyses, knowledge integration, as well as reasoning processes whenever they are necessary” (Kintsch, 2005, p. 127).

This model differentiates between a surface-level comprehension (textbase) and a deep, profound comprehension (situation model) of text by the reader. *Textbase* is when a reader “attempts to stay as close to the text as possible and to avoid augmenting the memory representation by activating background knowledge” (van den Broek, Young, Tzeng, & Linderholm, 2004, p. 1245). In other words, textbase is a literal representation of what was read and becomes a surface-level comprehension of the material. A *situation model*, also known as a mental model, occurs when a reader “attempts to

connect every aspect of the text to his or her background knowledge” (van den Broek et al., 2004, p. 1245). Background knowledge, also known as prior knowledge (Strangman & Hall, 2004), encompasses content knowledge, grammar, sentence construction, semantics, text coherence, vocabulary, and symbol knowledge. The situation model that readers create depends “very much on their goals in reading the text, as well as the amount of relevant prior knowledge that they have” (Kintsch, 2004, p. 1274). The situation model corresponds to a deeper level of comprehension that transcends the information in the textbook and connects with the student’s prior knowledge (Caccamise & Snyder, 2005). Representations of a situation model can be images, which may include mental images of maps and diagrams (Kintsch, 2004). Kintsch notes that there is not only one way to create a situation model. Most readers will more or less form a similar textbase, but the situation model will vary depending upon readers’ interests, purposes, and background knowledge. Together, textbase and situation models of comprehension work to integrate readers’ prior knowledge and new knowledge into the readers’ long-term memory for recall as needed, both inside and outside of the classroom.

The CI model does not define new content area reading strategies, but it does specify the intended purpose for existing reading strategies; that is to catalyze and integrate the reader’s knowledge. “Kintsch sees strategies as important for encouraging active processing that activates any existing background knowledge” (Cromley & Azevedo, 2004, p. 7). Therefore, activating background knowledge is needed to encourage deep, profound comprehension of a topic. The CI model provided theoretical grounding for this study’s investigation of content area reading strategies. The reading strategies designed for this study not only endeavored to activate students’ background

knowledge, but discussion questions were included to assist students in connecting background knowledge with new knowledge in order to encourage a situation model, namely a deep-level of comprehension of the selected mathematics material. Discussion questions were incorporated into all but one reading strategy designed for this study. The inclusion of discussion questions was intended to enhance the promising effectiveness of the reading strategies. This was achieved in two ways, by using multiple reading strategies (any one of the reading strategies designed for the study with the inclusion of the discussion questions) and by using the discussion questions themselves.

**Use of multiple reading strategies.** NRP (2001) reviewed 203 studies on the instruction of text comprehension and found there to be 16 effective comprehension strategies (reading strategies) of which eight were soundly based in scientific findings. Seven of the eight were individual strategies; however; the eighth was the strategy *of* teaching multiple strategies. The NRP report states that use of multiple strategies is effective in that they “improve reading ability and academic achievement” (NRP, 2001, p. 4-43). Additionally, several of the individual strategies listed by NRP were found to be effective when used as part of a multiple strategy instruction for comprehension of text. High school freshman in an English language arts course participated in a study to determine if experience with combined multiple reading strategies impacted comprehension of the subject matter (Alfassi, 2004). The findings indicated that the use of multiple reading strategies, embedded in the course, improved students’ reading comprehension when compared to students who were not exposed to the reading strategies. The researcher stated that incorporating reading strategies into the English language arts curriculum can have demonstrated educational benefits. NRP listed

“question answering” as one of the seven effective individual reading strategies shown to improve comprehension. Furthermore, the use of the discussion questions “may be best used as a part of multiple strategy packages where the teacher uses questions to guide and monitor readers’ comprehension” (NRP, 2001, p. 4-45).

**Use of discussion questions.** Students’ mathematical understandings will become more sophisticated as they work to communicate their reasoning (Simon & Blume, 1996). This is partly because students must be actively engaged to answer the questions. Discussion questions were included in this study as part of the content area reading strategies for three key reasons. First, the discussion questions were to aid students in making connections between their prior knowledge and new knowledge, concepts and procedures, and vocabulary of the mathematics academic language. In other words, the discussion questions were intended to assist students in actively developing a situation model of deep, profound understanding of the selected mathematics topics. Second, the questions were to aid students’ efforts to hear and talk mathematics with the proper academic language. When students talk about a topic, it helps them to make connections, deepen their understanding, and create mental representations (Athanases, 1989). The third key reason was to provide the instructors with a type of informal assessment of the students. Listening to the students’ answers and discussions could highlight misconceptions and inappropriate or incomplete definitions applied to mathematics vocabulary.

Eileen Kintsch wrote that discussion questions can target any one of three levels of comprehension processing (Kintsch, 2005). The first level consists of text-based questions which target specific information from the text. These questions can be

answered recalling a specific fact or definition. The second level also consists of text-based questions, however these target summary statements. While either a short or long constructed response is required to answer these questions, the information can be found explicitly in the text. Both of these levels are closely aligned with the textbase comprehension level from the CI model. The final level consists of inference questions which require the student to go beyond what is explicitly stated in the text. To answer these questions students must construct “novel connections between ideas, to form analogies, or to apply the text material to a novel problem. Answers to inference questions probe to what extent the learner has formed an accurate and complete mental model of what the text is about” (Kintsch, 2005, p. 59). Constructing comprehension at the textbase is fairly automatic; constructing comprehension for a situation model requires conscious effort (Kintsch, 2005), which is similar to Rosenblatt’s idea that a predominantly efferent reading stance requires effort from the reader.

The discussion questions created for this study were intended to target the second and third levels of comprehension processing. Not only did the questions cover the mathematics of concern but also the reading strategy itself. For instance, one reading strategy implemented was a self-evaluation metacognitive strategy covering one page of the textbook; students were to highlight the portions they understood in pink, otherwise they were to highlight in yellow. The discussion questions began by asking how the students read a mathematics textbook page differently from a page in a novel, what they did do while reading, and if it was a new approach for them to experience. This was followed with questions on the topic using a variety of what, why, and how questions. Another reading strategy in this study was a word sort; a portion of the questions asked

students to justify why they placed vocabulary words into the category or categories they did. In nearly all of this study's reading strategies the discussion questions included asking students to connect the concepts with the procedures and when warranted, with the relevant vocabulary.

### **Mathematics Principles of Learning**

In 2000, the National Research Council (NRC) published the seminal text *How People Learn* (Bransford, Brown, & Cocking, 2000). The intent was to move forward the understanding of how people learn by reviewing research in a variety of fields. From this book, three key principles of learning came forth. The three principles of learning were:

Principle #1: Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom (pp. 14-15).

Principle #2: To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application (p. 16).

Principle #3: A “metacognitive” approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them (p. 18).

In 2001, the idea of *mathematical proficiency* (Kilpatrick et al., 2001) was introduced to better capture all aspects of what research had shown as required to learn mathematics successfully. Mathematical proficiency has five intertwined strands.

- Conceptual understanding: comprehending mathematical concepts, operations, and relations—knowing what mathematical symbols, diagrams, and procedures mean.

- Procedural fluency: carrying out mathematical procedures, such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately.
- Strategic competence: being able to formulate problems mathematically and to devise strategies for solving them using concepts and procedures appropriately.
- Adaptive reasoning: using logic to explain and justify a solution to a problem or to extend from something known to something not yet known.
- Productive disposition: seeing mathematics as sensible, useful, and doable—if you work at it—and being willing to do the work (Kilpatrick et al., 2001, p. 116).

For a mathematics lesson to encourage students to become mathematically proficient, all five strands must work together. “In fact, it is almost impossible to master any one of the strands in isolation....Addressing all the strands of proficiency makes knowledge stronger, more durable, more adaptive, more useful, and more relevant” (Kilpatrick et al., 2001, p. 17). At times, only one or two strands may be emphasized for a portion of a mathematics lesson; yet all five strands should be covered at some point in a lesson. “Proficiency in mathematics develops over time. Thus, each year they are in school, students ought to become increasingly proficient with both old and new content” (Kilpatrick et al., 2001, p. 21). In other words, as students progress through school, their proficiency in mathematics should become deeper and more profound.

In 2005, *How People Learn* was followed by *How Students Learn: History, Mathematics, and Science in the Classroom* (Donovan & Bransford, 2005). This publication expanded upon the three principles of learning for each of the content areas listed and for three levels of schooling: elementary, middle, and high school. More specifically, contributors Fuson et al. contributed a chapter in which they explained how the five strands of mathematical proficiency “map directly” to the three principles of



learning (Fuson et al., 2005, p. 218). This provided theoretical grounding for incorporating content area reading strategies into the developmental mathematics course for this study. As previously noted, an underlying assumption for this study is that incorporating the selected content area reading strategies into classroom instruction would support the five strands of mathematical proficiency and therefore the three principles of learning. Essentially, for this study, the three principles of learning are being viewed through the lens of learning mathematics.

By definition, content area reading strategies “provide a purpose for instruction—to teach students, for example, how to activate prior knowledge, summarize and question, and organize information for recall and/or writing” (Conley, 2009, p. 532). The reading strategies were designed to connect procedural knowledge with conceptual knowledge, connect prior knowledge with new knowledge, and to connect vocabulary with the mathematics and notation. Additionally, each reading strategy handout was intended to engage the students in their own learning; the discussion questions for each reading strategy encouraged students to explain and justify their work. Furthermore, the handouts and/or discussion questions for each reading strategy provided the instructors with opportunities to determine what, if any, preconceptions the students may have. “One important way to make students’ thinking visible is through math talk—talking about mathematical thinking” (Fuson et al., 2005, p. 228). By making “thinking visible” through discussion, preconceptions and prior knowledge may become apparent for the instructor and the students alike. Content area reading strategies in this study were all designed with the intent of encouraging students to use the textbook. Metacognition is a very large component of the activity of reading. Students were to read the textbook for

the information needed to complete the handouts and to participate in the discussion that the questions engendered. The complete implementation of the reading strategies in the study using the handouts and discussion questions fully supports the supposition of Fuson et al. (2005).

### **Content Area Reading Strategy Foci in this Study**

Little research has been done by the mathematics education community that specifically looks at content area reading strategies which can be used by students to better their comprehension when reading a mathematics textbook. This is particularly true at the secondary level and beyond in mathematics classrooms (Fisher & Frey, 2008; Franz & Hopper, 2007). In addition, little research has been done to determine what teachers may already know and do to help their students better comprehend mathematics textbooks. In fact, when the specific focus is on secondary students' or college students' and their teachers' use of content area reading strategies for mathematics, the amount of research available is minute. Most research has been conducted with younger readers by literacy and reading experts devoid of context and the results then applied to a content area such as mathematics (Conley, 2009). However, mathematics poses many learning problems that reading and literacy experts have never envisioned, explored, or experienced (Conley, 2009).

The following sections discuss five predominant areas of focus for the eight content area reading strategies employed in this study. Each reading strategy focus consisted of one or more content area reading strategies to be implemented via 14 different tasks or assignments. Each of the eight reading strategies designed for this study included a handout which made it necessary for the students to use the textbook,

often working in pairs or small groups. Furthermore, instructors were required to explain explicitly to the students the purpose for the reading strategy, both the mathematics aspect and the reading aspect, and how the strategy was to be completed. Once students completed their handout, the instructors were to follow-up with discussion questions.

### **Text Features**

In this study, one area of focus was text features which used one content area reading strategy which focused on the features of the textbook (viz., get-to-know-your-textbook). Textbook features include several aspects such as organization, structure, colors, style, page spacing, fonts, print sizes, headings and subheadings, captions, and graphics. Well-structured coherent textbooks in any content area can improve a student's recall and comprehension of the text (Williams, 2007). Textbooks are often classified as "inconsiderate;" inconsiderate texts either violate accepted structure of a topic or genre or they are poorly written. When poorly written, it is often due to the encyclopedic quality of the textbook and to "being written by committees and consultants rather than authors" (Chambliss & Calfee, 1998, p. 8). Another factor which hinders students' ability to read a mathematics textbook is the need for the textbook to be "absolutely mathematically correct and complete so that it cannot be criticized by mathematical colleagues" (Hubbard, 1992, p. 81). Therefore, the textbook does not seem to be targeted toward student learning. By teaching students reading strategies which inform them about the layout and structure of their mathematics textbooks, their comprehension of the text can be improved (Smith & Kepner, 1981). "Some small but important amount of the textual information has to do not with the text's content, but with its structure. This structural

information helps readers organize the content information and construct their mental representation (i.e., the meaning of the text)” (Williams, 2008, p. 171).

In general, the research suggests that almost any approach to teaching the structure of informational text improves both comprehension and recall of key text information. One plausible explanation is that systematic attention to the underlying organization, whether intended by the authors of texts or not, helps students to relate ideas to one another in ways that make them more understandable and more memorable. Another plausible explanation is that it is actually knowledge of the content, not facility with text structure, that children acquire when they attend to the structural features of text. In other words, text structure is nothing more than an alias for the underlying structure of knowledge in that domain (Duke & Pearson, 2008/2009, p. 111).

While there are many studies on various parts of text features, there are few studies on comprehension of mathematics which take into account these features (Shanahan, 2009). Younger and older adults, of various ages, participated in a study on text recall (Meyer & Poon, 2001). Participants were placed into three groups for a study on text recall. Two of the groups participated in 9 hours of training in either structure strategy or interest strategy. The third group received no training. The reading strategy addressing text features was termed structure strategy, and it addressed the identification and use of the semantic content and structural organization along with other elements such as the headings, preview statements, and summary statements in the selected non-mathematics text. Participants in the interest strategy learned to make uninteresting topics more interesting to boost their motivation to recall the text. The participants in the structure strategy group were able to recall more of what they read and more of the important information than participants in the other groups (Meyer & Poon, 2001).

Children made aware of and taught how to identify text structure can often better comprehend expository text; this is particularly true for students with low levels of knowledge about a content area (Goldman & Rakestraw, 2000). Taking time to introduce

students to the text structure and organization of their textbooks could lead to increased student achievement in the content area being taught.

**Get-to-know-your-textbook strategy connection to theory.** This reading strategy was designed to focus on the text features of the course's prealgebra mathematics textbook and was grounded in Rosenblatt's Transactional Reading theory which suggests that readers transact with the text during the act of reading. Providing mathematics students with knowledge of the various textbook features and their purposes (e.g., boldfaced words are new vocabulary words), the students can better transact with the text. Mathematics textbooks have more text features than most narrative prose and understanding the nature of the textbook provides a type of "roadmap" for the organization of the information within. This reading strategy provides the students with a familiarity for their textbook which may encourage them to better interact with the text and therefore be better able to extract and retain the information desired.

While Rosenblatt's theory highlights the reader transacting with the text, Kintsch's CI model highlights the deepening of a surface level understanding to a deeper level understanding of the text in a mathematics textbook. The get-to-know-your-textbook reading strategy provides students with an understanding of how the textbook is organized and therefore, how the knowledge within is organized. By reading through a mathematics textbook by means of a "roadmap" for understanding the organization, students may move from a surface understanding to a deeper understanding of the information. Text features offer clues to the organization of the textbook information thereby providing the students with a conduit for making connections between concepts and furthering their understanding of the academic language. They are using their newly

acquired background knowledge about the text features, to make connections between their full background knowledge and the new knowledge, thus moving to a deeper level of understanding.

As Rosenblatt's theory and Kintsch's CI model do not focus on mathematical proficiency neither does the get-to-know-your-textbook reading strategy. However, it does focus on teaching students to transact with a text as a learning tool that then can lead to the deep understanding that Kintsch's model envisions. This reading strategy does clearly support two of the learning principles, Principle #2 and Principle #3. Principle #2 addresses the idea that students must organize their knowledge in ways that facilitate retrieval and application. Researchers have noted that text features help readers organize information which aids in recall (Williams, 2008). Furthermore, recall of knowledge is required for any application. Principle #3 addresses metacognition. Text features, for example the headings and subheadings, indicate the main idea and concept in the subsequent text. As students read that text, they can self-monitor their reading comprehension to determine if they understand what the heading or subheading was indicating.

### **Conceptual Understanding**

Two of the content area reading strategies designed for this study focused predominantly on conceptual understanding (viz., vocabulary, word sort). The vocabulary reading strategy highlighted the differences and similarities between everyday language definitions and mathematical definitions for vocabulary words. The intent was to make students aware of the multiple definitions that a vocabulary word may carry and which definition the student may be applying in mathematics. This strategy is important

because “seventy percent of the most frequently used words have multiple meanings” (Bromley, 2007, p. 531). The other reading strategy, word sort, can aid students in recognizing the semantic relationships among key concepts and increase conceptual understanding. When students sort words into categories they must consider the connections between and among the vocabulary words.

“Reading in mathematics necessitates that one understand the meaning of the words” (Capraro & Joffrion, 2006, p. 149). NRP (2001) reported that direct instruction of vocabulary leads to increases in comprehension; separating vocabulary from comprehension is nearly impossible. Similarly, the RAND Reading Study Group pointed out that “the relationship between vocabulary knowledge and comprehension is extremely complex” (Snow, 2002, p. 35). Vocabulary is best learned when students are actively engaged in learning tasks, and vocabulary should be learned in the context of the content area being studied (Blachowicz, Fisher, Ogle, & Watts-Taffe, 2006; NRP, 2001). Vocabulary is a vital component of comprehension. In other words, if students do not understand the vocabulary, even on a surface level, they will not comprehend the text they have read or develop conceptual understanding, much less be able to apply the information. Knowledge of vocabulary is needed for comprehension; however, at the same time reading comprehension facilitates an increase in vocabulary (Bromley, 2007, Nagy & Scott, 2000; Pressley, 2001). This happens because students link the vocabulary in their existing schema with the new vocabulary encountered. This enhances their ability to remember the new vocabulary words at a later time, thus increasing their vocabulary and knowledge (Rupley, Logan, & Nichols, 1999). Not only is knowledge of mathematics vocabulary necessary for comprehension of mathematics text, it is also

necessary in order to be able to communicate conceptual understanding mathematically in the mathematics classroom. In the Communication Standard of the NCTM's *Principle and Standards*, it is plainly stated that students should "use the language of mathematics to express mathematical ideas precisely" (NCTM, 2000, p. 60). This cannot be done without knowledge of vocabulary.

Fifth-graders were taught several reading strategies which focused on vocabulary such as using mathematics journals, student-created mathematics dictionaries, graphic organizers, and visual aids (Blessman & Mysczak, 2001). As a result the students showed an increase in comprehension and in their use of mathematical vocabulary in assessments and in communicating their ideas. Similarly, a study of secondary school students with low metalinguistic awareness (a component of language proficiency which is involved when a vocabulary word or its function is focused upon) suggested that supporting the language development of students' with low metalinguistic awareness would be an advantageous approach to increasing algebra achievement (MacGregor & Price, 1999).

**Vocabulary strategy connection to theory.** The focus of the vocabulary strategy was to encourage students to distinguish among various definitions that may be associated with a vocabulary word in their mathematics textbook and to apply the correct definition since it is understood that the context is mathematics. Per Ronsenblatt's theory, students should interact with a predominantly efferent stance when reading their mathematics textbook so as to competently apply the appropriate definitions to the vocabulary words they are encountering. As students become more adept at applying the appropriate definitions to the mathematics vocabulary, their conceptual understanding of



the mathematics should deepen which is more akin to Kintsch's situation model level of understanding, that is, a deeper, more profound level of understanding.

The vocabulary reading strategy is similar to the previously discussed get-to-know-your-textbook reading strategy as it too does not specifically address a mathematical topic. However, as stated, understanding vocabulary is essential to deeper levels of understanding. This understanding can be attended to clearly by all three principles of learning. When students apply alternative definitions to mathematical vocabulary, they can be working with preconceptions about the mathematics and this is clearly Principle #1. The vocabulary reading strategy can help students and their instructors become aware of and bridge the familiar, informal, everyday language definitions with the unfamiliar formal definitions of mathematics. Furthermore, the discussion questions which are part of this strategy may alert instructors to the preconceptions the students may hold.

Understanding requires both procedural knowledge and conceptual knowledge as given in Principle #2. Procedural knowledge is commonly considered the process of solving a "naked" mathematics problem, however, if the procedures are to be connected to conceptual knowledge, then knowledge of mathematics vocabulary is required. For example, students may be able to apply the procedures needed to solve a problem, but only if they can read and understand the directions, the problem, and relate the solution to the context of the problem in written and verbal forms. Lastly, Principle #3 addresses a metacognitive approach to instructional practices to help students become independent learners. Independent learners are able to apply the appropriate definitions to

mathematics vocabulary for increased understanding. A student must be adept at the language of mathematics to accomplish this.

**Word-sort strategy connection to theory.** A closed word sort was used in which students were given a list of vocabulary words and categories. The word sort encouraged students to transact with the textbook in order to justify why particular vocabulary words were placed into one or more categories. This encouraged a predominantly efferent reading stance, as defined in Rosenblatt's transactional reading theory, from the students as they extracted from the course textbook the definition of each listed vocabulary word and its relationships with the other vocabulary words in order to discern which category or categories the words should be placed. The relationships between and among various vocabulary words is more inferred from the textbook than explicitly stated, therefore, more effort was required of the students.

Furthermore, as students transacted with the textbook to distinguish how the various vocabulary words were related to one another, the students may have moved from a surface understanding to a deeper understanding to build conceptual understanding of the mathematics. This deepening of understanding is attended to by Kintsch's CI model. Since the word sort strategy was designed to be a Unit review for each course examination, it provided vocabulary words from several sections and chapters in the textbook. Students needed to activate their background knowledge while transacting with the text to make inferences about the connections between and among vocabulary words. Therefore, connections between procedures and concepts were also made across the sections and chapters, thus possibly strengthening conceptual understanding.

The word sort strategy does address each of the three principles of learning. This strategy connects with Principles #1 and #3 the same way as the vocabulary strategy. However, Principle #2 and the word sort strategy are strongly connected. In a way, the individual vocabulary words can be thought of as “factual knowledge” whereas the categories can be thought of as “conceptual knowledge.” For example, one word sort category given to the students was *Related to Fractions*. Some vocabulary words that students placed in this category were as follows: complex fraction, improper fraction, lowest common denominator (LCD), lowest terms, mixed number, proper fraction, proportion, rate, ratio, rational number, and reciprocal. Students may understand the definitions of proper and improper fractions, but may not understand how each relates to the concept of ratio. In this analogy, the conceptual knowledge is the topic of fractions and the factual knowledge is the various forms of fractions, however, when a student is able to connect the factual with the conceptual, then true conceptual understanding should be reached.

### **Visual Representations of Text**

There were two reading strategies designed for this study which clearly focused on various visual representations to present selected mathematical topics in an alternative format from the textbook (viz., concept map, word-problem solving guide). The concept map reading strategy actually consisted of three concept maps which were all implemented closely together during the semester and all three attended to the same mathematics topic, decimal-fraction-percentage conversions (viz., Concept Map 1, Concept Map 2, Concept Map 3). Concept Map 1 focused on converting from decimals to fractions, while Concept Map 2 focused on the reverse. Concept Map 3 differed from the

first two concept maps in that is was a labeled 3x3 array. It focused on all six conversions; percent to decimal, decimal to percent, fraction to percent, percent to fraction, decimal to fraction, and fraction to decimal. The remaining reading strategy was a word-problem solving guide based on Polya's four-step process.

Visual representations have many forms and names such as: concept maps, graphic organizers, semantic maps, story maps, mind mapping, webs, and tree diagrams. NRP (2001) identified graphic and semantic organizers as one of the seven reading strategies that had a solid scientific basis for concluding that their use improved memory and comprehension. Graphic and semantic organizers are a type of reading strategy "that allow the reader to represent graphically (write or draw) the meanings and relationships of the ideas that underlie the words in the text" (NRP, 2001, p. 4-6). Various visual representations can help students focus on text structure while reading, provide tools to examine and visually represent relationships of information from the text, and assist in writing well-organized summaries (NRP, 2001). "Making connections between old and new knowledge, may be cognitively facilitated by organizing and constructing, and visually communicated through, maps/diagrams" (Afamasaga-Fuata'I, 2009, p. 240).

The word-problem solving guide designed for this study is a graphic organizer to "guide" students through approaching and solving a word problem. It provided more guidance than Polya's four-step process as presented in the course textbook (Wright, 2008, p. 685).

1. Understand the problem. (Read it carefully and be sure that you understand all the terms used.)
2. Devise a plan. (Set up an equation or a table or chart relating the information.)
3. Carry out the plan. (Perform any indicated operations in Step 2.)

4. Look back over the results. (Ask yourself if the answer seems reasonable and if you could solve similar problems in the future.)

A study with fifth-graders using a graphic organizer to solve word problems indicated that students seemed to benefit from the more systematic approach. A key reason given for the effectiveness of the graphic organizer was that students found it necessary to slow down in order to think about each step of the problem. It also allowed weaker students to visually see the organization of the word problem-solving process (Braselton & Decker, 1994).

Undergraduate students were given text from a textbook in a sociology of education course in one of four formats: original text (approximately 3500 words), original text with a tree diagram which was not incorporated into the text, original text with the same added tree diagram but with an explanation within the text referring to the tree diagram, and an elaborated text version that highlighted the critical relations with marginal notes, different type face, subheadings, and additional explanations of the relations between various parts of the text without the tree diagram (Guri-Rozenblit, 1989). The tree diagram was used to represent the main idea of the text and the students were not instructed how to create one. Once assessed on the selected text, the groups who had a tree diagram with and without explanation performed significantly better than the groups who had text only or the elaborated text version. For questions that focused on more subtle relationships from the text, the tree diagram with explanation group had superior performance. This result implies that if students are given information with a graphic and explanation they will have a deeper understanding of the text.

**Concept map strategy connection to theory.** Concept Maps 1 and 2 were diagrams with lines drawn between associated concepts showing relationships and pertinent vocabulary (e.g., terminating number, repeating number). There were blank bubbles in which students were to provide information from the textbook about the conversion and write relevant examples which they found helpful. Concept Map 3, a labeled 3x3 array, built off of the information in the first two concept maps. While the first two concept maps focused on one conversion each, Concept Map 3 focused on all six conversions. This required students to transact with the textbook and the first two concept maps to complete the cells in the labeled 3x3 array. Students extracted information from the textbook and the first two concept maps on the process for each of the six conversion processes and included a relevant example for each. Rosenblatt's Transactional Reading Theory would describe this purpose for reading to be a predominantly efferent stance, the students were extracting information. For all three concept maps, once the information was extracted it was placed into the bubbles or cells which not only organized the information differently from the textbook, but also provided a visual representation.

As students transacted with the textbook to complete the bubbles and cells in the three concept maps, they deepened their understanding of the six conversion processes and associated vocabulary. Essentially, in Kintsch's CI model, students' situation models of understanding were encouraged by the visual representations of the conversions. In other words, by allowing students to see the conversions in a visual representation which differed from their textbook, their retention and comprehension of the conversions may have improved and this would have deepened their level of comprehension.

Taken together, all three concept maps are most strongly connected with Principle #2 of the three learning principles. Of course, the process for each conversion would be procedural knowledge however, when the six conversions are compared, conceptual knowledge is required for understanding. Students were able to take the six conversion processes and apply a new organization onto them thereby possibly increasing retention. Thus, students' conceptual understanding may improve by realizing that a numerical value can be represented as a decimal, as a fraction, and as a percentage and still be equivalent.

Additionally, the students could conceptually organize the conversions in Concept Map 3 according to the procedures required. For example, when converting from a fraction to decimal, students divide the denominator into the numerator yet, to convert from a decimal to a percentage, students multiply the decimal by 100. Both are essentially a one-step process. However, to convert from a fraction to a percentage, students first perform the conversion procedure from the fraction to the decimal, then perform the conversion procedure from the decimal to the percentage. Therefore, students should become aware that the complete conversion process from a fraction to a percentage is not a completely different conversion; it consists of two one-step conversions.

**Word-problem solving guide strategy connection to theory.** The word problem solving guide strategy guided students' approach to and process through solving a word problem. The guide is formatted into several boxes on a single page with each box having a specific focus. The boxes flow from the approach, to the mathematical solution process, to the explanation and justification of the solution.

Often students become paralyzed when asked to solve word problems; they often do not know how to translate the English of the word problem into the mathematics required for the solution process. Solving the mathematics is possibly the easiest part of word problems for students. This reading strategy asks students to first determine what is being asked, that is, to determine the unknown. Next, students are asked what useful information is available in the word problem as students often assume every numerical reference in a word problem is to be used in the solution. This question is asked due to the fact, that mathematics textbook authors will frequently include a numerical value that is unrelated to the word problem solution. For example, students are given the values for rate and time and asked to find the distance traveled by 6 people traveling together in a single vehicle. The fact that there are 6 people is irrelevant to the solution, only the values for rate and time are required. These first two questions provide students with an alternative approach for word problems, offering them a “toe-hold” to get started. It also encourages them to transact with the text of the word problem to extract the initial information needed to get started.

The third question in the guide asks students to list ideas they may have for what mathematical procedure should be used for the solution which is to be accomplished in the next box. The context of the new information being learned or students’ background knowledge may offer clues. Where Rosenblatt’s Transactional Reading Theory puts forth that the students are transacting with the text of the word problem in a predominantly efferent stance, Kintsch’s CI model encourages students to connect their background knowledge of previously learned word problem approaches and solutions with the new information being presented and applied. The more students interact with



various types of word problems the more background knowledge they have to draw upon in order make these connections and, therefore, deepen their comprehension of approaches and solutions for many types of word problems.

This reading strategy connects strongly with Principle #1 and Principle #3. When asked to solve a word problem, students will recall any prior understandings they have from previous experiences. Elementary students are commonly taught to read a word problem and pick out the “key” words (e.g., *twice* means to multiply by 2, *more than* means to add) in order to solve a word problem. Therefore, students will approach word problems with preconceived ideas about what should be done and this is clearly Principle #1. The use of key words is not an approach that will work for all word problems and when the use of the key word approach fails, students become frustrated. The word-problem solution guide offers an alternative process that does not rely on key words.

Principle #3 identifies “providing support for self-assessment is an important component of effective teaching” (Fuson et al., 2005, p. 12). This reading strategy supports students with their approach to and solving of word problems. As students read the word problem with the intention of answering the first two questions, they are assessing their understanding of the word problem as well as starting to form ideas for what mathematics are required for solving.

### **Sequencing**

This study designed one reading strategy which focused on the sequencing of the steps in a mathematics solution (viz., scrambled solutions). Solution steps of a solved mathematics problem were given to students in a scrambled order that was not in the expected order of a properly completed solution. Students were to place the steps in the

proper order and to justify the algebraic manipulation in each step with the appropriate property/identity/principle and an explanation. In other words, the students were to “read the text clues” of a solution step to sequence the steps of the problem properly by determining which algebraic manipulation is required. Text clues in mathematics, for example, can occur when students observe that the coefficient of a variable is a fraction and should be cleared or when the variable is still on both sides of the equation. These text clues indicate which property/identity/principle the student should apply to a solution step in the sequence and why. Purposely, this reading strategy encouraged students to do “mindful manipulation,” which is one of the key elements of reasoning and sense making with algebraic symbols (NCTM, 2009, p. 31). Algebraic manipulation, done mindfully, is “a process guided by understanding and goals...and seeing that the basic rules of arithmetic provide a rationale for all legitimate manipulations of polynomial expressions” (NCTM, 2009, p. 33).

When solving a problem, students are expected to transform the symbol expressions in the original equation to the final answer form by performing a sequence of symbol manipulations. It is important to note that each step of the solution process is a hierarchically arranged set of procedures progressing from one step to the next. This can be defined as procedural knowledge, which consists of two distinct parts (Hiebert & Lefevre, 1986). The first part “is composed of the formal language, or symbol representation system, of mathematics. The other part consist of the algorithms, or rules, for completing mathematical tasks....A key feature of procedures is that they are executed in a predetermined linear sequence” (Hiebert & Lefevre, 1986, p. 6). Conceptual knowledge “is characterized most clearly as knowledge that is rich in

relationships [and] must be learned meaningfully. Procedures, on the other hand, may or may not be learned with meaning” (Hiebert & Lefevre, 1986, pp. 3-4). However, procedures learned with meaning are connected to conceptual knowledge and are more easily recalled, not just memorized for the short-term (Hiebert & Lefevre, 1986). It is possible to have procedural knowledge without conceptual knowledge, although, it is extremely difficult to have conceptual knowledge without procedural knowledge. This is because “procedures translate conceptual knowledge into something observable. Without procedures to access and act on the knowledge, we would not know it was there” (Hiebert & Lefevre, 1986, p. 9).

The researcher of this study was not able to find any research indicating that this reading strategy had been adapted for mathematics in the manner used in this study. Furthermore, researchers in Hungary who studied the reading strategy, sequencing sentences into a coherent paragraph, reported that they are not aware of any research “into, or even descriptions of the use of, this promising task type” (Alderson, Percsich, & Szabo, 2000, p. 424). In Hungary, this reading strategy is a popular method for testing reading ability of students (Alderson et al., 2000). Their study was able to show a positive correlation between secondary students’ overall reading ability and their ability to properly sequence sentences into a paragraph, they also believe further research should be done to validate this reading strategy. A more recent study was conducted with upper-elementary students in which sequencing sentences in a coherent paragraph was part of a versatile sentence completion strategy (Montelongo & Hernandez, 2007). These researchers claimed that the activity of sequencing sentences into a coherent paragraph allowed students to sharpen their thinking and writing skills as they worked to put the

sentences into a sequence which made sense. This included increasing their awareness of text clues such as signal words which “clue” the reader to the intended structure of the text, thus placing the sentences into the proper order. When students used signal words and logic, they were more apt to properly sequence the sentences (Montelongo & Hernandez, 2007).

**Scrambled-solutions strategy connection to theory.** Rosenblatt’s Transactional Reading Theory presented the transacting that readers do with text to be done with prose. However, in mathematics the text can be in the form of symbols, numbers, and notations. In the situation of solving an equation, students must transact with these symbols, numbers, and notations. In each step of the solution process, the students transact in a predominantly efferent stance since they need to extract from each step indications of what the next step may be. This process certainly requires students to be effortful in the process of transacting with this type of mathematical text.

As students transact with the mathematical text, they must draw on background knowledge to be able to read and comprehend the “text clues” in each step with the aim of indicating which property/identity/principle allows the next step to occur. Together, the surface understanding of the symbols, numbers, and notations in the mathematical text with the conceptual knowledge of the property/identity/principle applied develops into a deeper, more profound understanding of the solution process. This is indicative of Kintsch’s CI model.

Similar to Kintsch’s CI model’s blending of surface understanding with conceptual knowledge, Principle #2 of the three learning principles blends factual knowledge into a conceptual framework. This is particularly true for the reading strategy

of scrambled solutions. The factual knowledge is the knowledge to accomplish the procedures for each step; however, the conceptual framework is the property/identity/principle which allows the procedure to be performed. As students read each step of a solution process and executes it, they must consistently ask themselves if it made sense. They must evaluate their own work as well as their understanding of what was done and why they were able to do it. This is by characterized by Principle #3.

### **Metacognition**

There were two content area reading strategies in this study which focused heavily on metacognition (viz., independent study-guide, self-evaluation). One was designed as a type of guide to help the students complete an independent study assignment for two sections of the course textbook (test of divisibility, prime and composite numbers) without the customary classroom lesson on the topic. These two sections were considered to be review material. The second strategy was designed as a silent reading activity to make students aware of reading strategies to use when reading mathematics text. A common student objective when reading nonfiction, also known as expository text, is to read from the beginning to the end, “straight through without stopping to ask why questions, reread, or take notes” (Block & Pressley, 2007, p. 234). Very little is retained, much less comprehended when using this style of reading for exposition. In Rosenblatt’s Transactional Reading Theory, this type of reading would be considered a predominantly aesthetic stance as the student is not effortful in their reading and not capable of extracting or retaining information from the expository text. Teaching metacognition strategies exposes students to and makes them aware of “fix-up” or repair strategies to use when their reading comprehension is stalled. Fix-up strategies can be

taught and may include rereading, restating what was read, reviewing the previously read text, looking forward in the text, and slowed reading (NRP, 2001; Snow, 2002).

Researchers agree that readers better understand and learn more from written material when they are aware of and monitor their comprehension, a vitally important facet of skilled reading (McNamara, 2004; Mokhtari & Reichard, 2002).

Researchers (Paris & Winograd, 1990) have shown that metacognitive strategies in which students become aware of their own thinking as they read, write, and solve problems can support academic learning and motivation. Students' awareness can be improved by the instructor simply discussing metacognitive strategies. Paris and Winograd (1990) argued that by raising students' awareness of metacognition there are two benefits: students, not teachers, become responsible for monitoring their learning and it fosters independent learning.

Study guides are instructional tools to assist students with their comprehension of new material by setting a purpose for reading. Study guides come in a variety of formats and can include elements such as vocabulary, fill-in-the-blank, and short answer questions (Dickenson, Miller, & Devoley, 2005). Instructors can design study guides to aid students in discerning which portions of a textbook section are important and which are not, essentially supplying a reading roadmap (Cunningham & Shablak, 1975). Students often lack this sophistication. Guiding questions can be embedded to encourage students to engage in metacognition: Did I understand what I read well enough to answer this question?

Studies show a general positive relationship between the use of study guides and student learning. One study reported using study guides designed for all content areas in

Grades 6-12 and observed two favorable results (Cunningham & Shablak, 1975). First, student comprehension increased with purposeful guidance via a study guide followed later by sustained comprehension without the need for a study guide. Second, students frustrated with reading efforts found the support they needed to better comprehend the material and were then able to continue with success.

Two studies with psychology undergraduates showed no significant positive correlation between student examination performance and the use of study guides (Balch, 2001; Gurung, 2003). A possible explanation given was that there was a mismatch between the focus of the study guide and the student assessment. Regardless of the results of these two studies, neither researcher thought study guides were futile.

**Independent study guide strategy connection to theory.** The study guide provided students with a purpose and a guide for doing the independent study assignment. Developmental mathematics students have very little experience with independent study and therefore, have probably had little instruction on how to actively transact with the text productively, particularly in what Rosenblatt defines as a predominantly efferent stance. This guide helped the students to engage in a predominantly efferent stance, page-by-page, when reading through the independent assignment by asking questions, highlighting important points and text features, and encouraging appropriate vocabulary definitions. While the independent study guide guided students to transact with the textbook in a predominantly efferent stance, the guide also illustrated for the students how to read beyond what was merely on the page. For example, this was done by asking the students to notice how two example problems were stated in order to answer the question “What operations do you expect to use when you

read *divide the product?*” The connection with Kintsch’s CI model primarily comes from the fact that this independent study assignment was review material. Therefore, the study guide was purposefully written to activate students’ background knowledge on the topic. By activating their background knowledge the guide helped students to increase their level of comprehension of the review material and thus possibly provide a more solid foundation for the remainder of the course material.

It is obvious that the study guide strategy connects strongly with Principle #3 as the guide used a metacognitive approach to instruction. The guide was designed to help students experience taking control of their own learning by providing the goal for them and asking them questions about their understanding as they progressed through the independent study sections.

**Self-evaluation strategy connection to theory.** Students were given highlighters to use while reading which forced students to transact with the text as they read in order to decide if each word or sentence should be highlighted in pink or yellow (pink for understanding, yellow for not understanding). The use of highlighters forced a predominantly efferent stance by the student while reading the textbook page. As Rosenblatt’s Transactional Reading Theory informed about students’ transaction with the text, Kintsch’s CI Model defined the value of that transaction. As the students read each word and line to decide which color highlighter to use, they had to activate background knowledge to make connections with the new knowledge to determine if it made sense.

Once more, it is obvious that this reading strategy is strongly connected to Principle #3, especially since it was designed to be a metacognitive strategy. The discussion questions following completion of the handout, asked the students how their



reading changed due to using the highlighters, how did they decide which color highlighter to use, and what types of questions did they ask themselves as they read. This was intended to make students aware of the “fix-up” reading strategies that are available to them.

### **Conclusion**

In summary, the studies presented in this chapter give support to the claim that incorporating content area reading strategies into the instructional practices of a prealgebra developmental mathematics course may be advantageous for students’ mathematics achievement. Students’ understanding of mathematics may deepen if students are provided with reading strategies to connect their prior knowledge with newly introduced mathematics topics and to blend their procedural knowledge with conceptual knowledge.

Little research has been conducted exploring the intersection of reading strategies, prealgebra mathematics, and community college students. This study specifically developed reading strategies which positioned developmental mathematics community college students to interact with their prealgebra textbook for more than examples and homework problems. By investigation, this study adds to and extends the literature in both reading and literacy education and mathematics education. Furthermore, this study extends two reading theories, Rosenblatt’s Transactional Reading Theory and Kintsch’s CI model of text comprehension, and the principles of mathematics learning to the use of and design of content area reading strategies for a prealgebra developmental mathematics course at a community college.

This study will endeavor to answer three research questions. The first research question will determine the impact of instruction incorporating content area reading strategies on the mathematics achievement of students in a community college, prealgebra, developmental mathematics course. The second research question ventures to determine what, if any, demographic factors influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course. The final research question asks what, if any, prior educational background of the enrolled students influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course. Together, the last two research questions examine whether demographic factors or prior knowledge interacted with the effectiveness of the treatment.

### **Chapter 3: Method**

This study utilized a quantitative control-treatment design to investigate whether the incorporation of content area reading strategies into the instructional practices of a community college's prealgebra developmental mathematics course would effect students' overall mathematics achievement in the course as measured by standardized course assessments and the course passing rate. Participants were community college students enrolled in a regularly offered developmental prealgebra mathematics course at a cooperating community college during a spring semester. Approximately one half of the students did have content area reading strategies incorporated into their course instruction (treatment group) and the remaining students did not have content area reading strategies incorporated into their course instruction (control group) by their assigned instructors. Student demographic data were collected as control variables as were instructor professional and demographic data. Furthermore, observations of selected treatment and control class meetings were conducted.

#### **Context of the Study**

##### **Community College**

The study accessed the students and instructors in a single developmental mathematics course offered by a cooperating community college in the mid-Atlantic region during the Spring 2010 semester. The cooperating community college operates four locations, identified by three distinct campuses and one multi-college classroom center where three different colleges offer courses. This community college offers more than 130 programs of study with approximately 10,000 credit-seeking and 12,000 continuing education students.

This community college designates only two courses as developmental mathematics: basic mathematics and prealgebra. Lecture and web-hybrid formats of the developmental mathematics courses are offered at all four locations of the community college. For the prealgebra developmental mathematics course, the subject of this study, both formats require students to purchase the same textbook as well as the same licensed computer software. The lecture format meets twice a week for 80 minutes for each class meeting. Classes meet on Monday/Wednesday or on Tuesday/Thursday. The web-hybrid format meets once a week for 105 minutes. Both formats incorporate the computer software; however the web-hybrid incorporates the software to provide instruction for the students while the lecture course uses the software for review of concepts and practice. This study only accessed students enrolled in the lecture format of the prealgebra course. During the Spring 2010 semester, 20 sections were offered in the lecture format; 18 of those sections participated in this study.

### **Faculty**

The names of the instructors and their contact information were provided to the researcher by the community college's Department of Mathematics, Physics, and Engineering. Prior to the beginning of the Spring 2010 semester, the researcher contacted each instructor assigned to teach the identified developmental mathematics course and solicited their participation according to approved Human Subjects procedures as defined by the University of Maryland and the cooperating community college. Those instructors who agreed to participate completed a consent form and were informed that they could withdraw from the study at anytime. No instructor chose to withdraw. Of the 16 available instructors teaching 20 sections of the prealgebra developmental

mathematics course, 14 agreed to participate teaching 18 sections. During an initial meeting with the 14 instructors the study was discussed and the instructors were able to choose whether to participate as a treatment or a control instructor. Consequently, students in a treatment instructor's section were part of the treatment group and students in a control instructor's section were part of the control group.

At the cooperating community college, both full-time and adjunct faculty members are assigned to teach developmental mathematics courses with one instructor assigned for each section, although instructors can be assigned to more than one section of a course. The developmental mathematics course assessed for this study is taught predominantly by adjunct instructors. Section assignment is by faculty choice with full-time faculty choosing first; adjuncts are then hired to cover the remaining sections. Adjunct instructors come to the classroom with a variety of backgrounds and teaching experiences, although the college does make an effort to ensure a standard of content knowledge. The community college's Department of Mathematics, Physics, and Engineering posts the following requirements for adjunct instructors:

- Bachelor's degree is required, but Masters degree is preferred;
- Subject matter/content expertise in your field as expected;
- Teaching experience is preferred; and
- Enthusiasm and passion for student learning and ability to respond to the needs of students using a variety of teaching methods are expected.

This community college has only one full-time mathematics faculty member dedicated to teaching multiple sections of each of two developmental mathematics courses. This instructor taught three sections of the developmental mathematics course accessed in this study. This faculty member also serves as the course leader to ensure a

standard of content and assessment for all sections of each developmental mathematics course offered at each location. The course leader is responsible for two different levels of developmental mathematics courses (basic arithmetic and prealgebra) with each offered in two different formats (lecture and web-hybrid). Each of these four course offerings has a unique structure and the course leader creates the syllabus and schedule, chooses the textbook and software, and provides software training for all instructors (full-time and adjunct) for each course. In addition, each semester for each course, the course leader furnishes all assigned instructors with a syllabus containing the grading guide and topic schedule, all quizzes, all Unit examinations, and the cumulative final examination for the course. Every instructor is expected to use the furnished materials when teaching the course.

Instructors for 18 of the 20 sections scheduled for the Spring 2010 semester via the lecture format of the course consented to participate in this study. The 18 sections were staffed by 14 instructors, of which only three were full-time faculty members. Each instructor taught only control or treatment sections.

As the study progressed, it became evident that one of the adjunct instructors teaching two of the control sections was not adhering to the syllabus and uniform examination requirements. Because these sections would yield censored data, these sections were not included in any of the reported data descriptions or analyses that follow. Thus this study assessed 16 sections taught by 13 instructors. Of the 13 instructors, seven volunteered to serve as treatment instructors (9 sections with 1 instructor assigned to 3 sections) and six instructors taught seven control sections (1

instructor assigned to 2 sections). Two of the treatment-section instructors and one of the control-section instructors were full-time faculty members.

## **Students**

All of the study's potential student participants placed into the course via one of three routes: achieving the minimum required score on the mathematics placement test, successfully completing the pre-requisite mathematics course (basic arithmetic), or repeating the course. Students who chose to register for the lecture format of the identified developmental mathematics course were able to enroll in any available section. Determining factors included their semester schedule, work schedule, or preference for an instructor, time, or location. This study collected data on all students (none of whom were minors) and faculty who freely consented to participate. Course sections, not individual students, were assigned to treatment or control status; instructors who volunteered to deliver the reading strategy instruction were identified as instructors of the treatment sections. All sections, treatment and control, followed the same course syllabus and schedule for teaching mathematics content; instruction in the treatment sections incorporated content area reading strategies.

During the first 2 weeks of the semester, the researcher visited each participating developmental mathematics section, both treatment and control. The researcher explained the study to the students, asked for their participation, and distributed two copies of the consent form to each student. All students were asked to return one copy of the consent form to the researcher: signed if they consented to participate, unsigned if they declined to participate. Information in the consent form explained how to withdraw

from the study at any time and how to contact the researcher to do so. This process ensured that it was not obvious either to the instructor or to other students as to which students did or did not opt to participate in the study. The instructors were never made aware of which students consented to participate.

There were 339 students registered for the 16 participating course sections, of which 235 students consented to participate. One student withdrew from the study; 17 students formally dropped the course for reasons unrelated to the study. After the fifth week of the semester, an additional 35 students stopped attending class and completing assignments/examinations for unknown reasons (22 treatment students, 13 control students). Because of the amount of missing data associated with these students, they were eliminated from the analyzed sample. Thus there were 179 students from whom complete data sets were acquired.

### **Course Expectations**

According to the syllabus grading guide, grading for this developmental mathematics course is Pass/Fail/In Progress. For a rating of Pass, students must earn at least 80% of the 780 course points available, that is, 624 points. Table 2 presents the point allocation for the course. To receive an In Progress (IP) grade students must show consistent effort and measurable achievement throughout the semester and not be absent from class more than three times. An IP grade is not a passing grade and may be considered a failing grade for students enrolled in tuition reimbursement programs. Students who earn a grade of IP must enroll in and complete the course in the next semester. The grade of IP is then changed to either the grade earned in the subsequent semester or Fail (no subsequent course completion). The data collection in this study



included the quiz grades, the Unit examination grades, the cumulative course final examination grade, and the total number of points earned in the course by each student.

Appendix A contains the complete course syllabus.

Table 2

*Course Point Allocation by Assignment*

Assignment	Total Possible Points (%)
17 Preview Assignments	51 (6.5)
10 graded Practice Assignments	100 (12.8)
Notebook	20 (2.6)
7 Quizzes <sup>a</sup> (drop lowest quiz)	84 (10.8)
8 Software Chapter Reviews	120 (15.0)
3 Unit Examinations <sup>a</sup>	225 (29.0)
Cumulative Final Examination <sup>a</sup>	180 (23.0)
Total Possible	780 (100.0)

<sup>a</sup> Assignments which compose the Utilized Course Points variable.

### **Data Sources**

This study gathered both quantitative and qualitative data. These data permitted a comparative analysis of the control and treatment group mathematics achievement.

Quantitative data on each participating student came from three sources. The sources were student achievement (e.g., quizzes, course examinations, final examination, course total points) provided by the instructors, student data records (e.g., placement scores, birth date, gender, race/ethnicity, program of study) provided by the college, and student

questionnaires (e.g., high school graduation year, last high school mathematics course topic).

The questionnaires, for student and faculty, were designed by the researcher and provided information that was used for descriptive data and control variables. The student questionnaire information provided further background information on each student. Additional quantitative data on participating faculty were gathered through faculty questionnaires. The faculty questionnaire provided information about each instructor's education and educational employment history (e.g., number of years teaching at this college, level of degree).

Qualitative data came from classroom observations of both treatment and control sections and faculty interviews. The qualitative data were gathered to further explain findings from the quantitative data. Classroom observation data were recorded through field notes. All 13 participating faculty were interviewed about their experiences and perceptions of teaching developmental mathematics. The seven participating treatment instructors were additionally interviewed as regards their incorporation of the content area reading strategies.

### **Student Questionnaires**

This questionnaire contained six questions addressing the students' prior academic background and competing demands (see Appendix B for student questionnaire). Samples of the questions are as follows: What year did you take your last mathematics class in high school (or for GED)? What was the title of the last mathematics class you took in high school (or for GED)? In an effort to preserve privacy, every student was assigned a unique identification number for this study. Each

questionnaire had a student's study-identification number on it and the student's name; the student's name was printed on a peel-off label. When each student received a questionnaire, a box was pre-checked by the researcher that indicated whether the student had or had not signed a consent form. Students who had not signed a consent form were instructed to not complete the questionnaire and to return it when the class was instructed to do so. Everyone was asked to remove the peel-off label before returning the questionnaire. This was done to preserve students' privacy as to whether they had consented to participate or not. The researcher later compared completed questionnaires with signed consent forms. At a later date, an effort was made to reach students who had been absent on the day the questionnaire was given and to reach students who did complete the questionnaire but had not previously signed a consent form.

### **Student Data Records**

The college provided data on each participating student. These data provided the following information that was used as a source of descriptive data and control variables: gender, race/ethnicity, birth date, mathematics placement score, English placement score, reading placement score, prerequisite mathematics course (Yes/No), number of prior registrations in this developmental mathematics course, program of study, number of semesters attending cooperating community college, and high school graduation year.

### **Student Achievement**

This course, at the community college, is an extremely standardized course. This is in response to the course instructional staff being mostly adjunct instructors who have varying levels of college and graduate education and teaching experience. Additionally, the developmental mathematics courses are expected to provide a consistent mathematics

foundation as needed for the subsequently required mathematics courses. This is particularly important since large numbers of the student population enroll in developmental mathematics courses. Therefore, the course leader provides all instructors with course expectations, schedule, quizzes, course examinations, and final examination. The standardization of the course extends to the grading guide and the requirements to pass the course. In this study, points earned by each participating student for each quiz, course examination, final examination, and total course points, as provided by the instructor, were used in the analyses.

### **Faculty Questionnaires**

The faculty questionnaire presented six questions addressing education and educational employment history (see Appendix B for faculty questionnaire). Samples of the questions are as follows: What is your highest degree level? What content is (are) your degree(s) in? Do you have or have you had a K-12 teaching certification? In an effort to preserve privacy, every instructor was assigned a unique identification number for this study. Each questionnaire had an instructor's study-identification number on it and was administered at the same time as the student questionnaire.

### **Faculty Interviews**

Every interview was conducted at a time and place convenient for each instructor, outside of the classroom. In order to acquire further descriptive information regarding faculty members' perspectives on teaching developmental mathematics, an interview script was developed. This script consisted of eight questions which were designed to be provided to the instructors, treatment and control, prior to the interview. These questions focused on how they came to be teaching this course, their perception of student strengths

and weaknesses, and what they found to be challenging and rewarding about teaching this course (See Appendix C for faculty interview questions).

A second interview script was developed for individual administration to the treatment instructors at the end of the semester. This interview consisted of 13 questions which were again provided prior to the interview. This interview focused on the implementation of each content area reading strategy (See Appendix C for faculty interview questions).

### **Classroom Observations**

Multiple classroom observations were conducted by the researcher in all sections, treatment and control. The classroom observations were conducted to verify the implementation of the reading strategies in the treatment sections although no criteria were used to address the quality of implementation. These observations of the treatment sections provided data addressing: explanation of the purpose for the strategy, explanation of the strategy's connection with the mathematics, clearly explained strategy directions, alignment with implementation directions in the researcher provided guide, and use of discussion questions. The classroom observations of the control sections were conducted to ensure that reading strategies were not being implemented and to ensure that the mathematics content and instructional design were comparable to that in the treatment sections. The researcher prearranged each classroom observation with the instructors. This was to ensure that in treatment sections a reading strategy was planned for that class session and in control sections to ensure that a course examination was not planned. During each observation, the researcher took field notes and did not participate

in the class. Exceptions to this were when the researcher asked for student participants for the study and when administering both the student and the faculty questionnaires.

### **Faculty and Student Participants**

#### **Faculty**

As revealed by the faculty questionnaire, the 13 instructors who participated in this study reflected varied personal and professional demographics. Table 3 displays the information gathered. It is interesting to note that nearly 50% of the participating instructors hold an education degree and nearly 50% hold (or have held) teacher certification. Furthermore, over 60% of the participating faculty hold a Masters' degree. More specifically, 67% of the full-time and 60% of the adjunct faculty hold a Masters' degree. AMATYC reports that nationally in 2005, 82% of full-time and 72% of adjunct mathematics faculty held a Masters' degree (2006, p. 4). The faculty percentages in this study seem to be aligned with the percentages in the national study when the small sample size of this study is taken into consideration.

Table 3

*Faculty Demographics and Educational Background*

Characteristics	Treatment			Control			All Instructors
	Adjunct	Full-time	Total	Adjunct	Full-time	Total	
<i>n</i> of teachers	5	2	7	5	1	6	13
Gender (%)							
Female	60.0	100.0	71.4	60.0	0.0	50.0	61.5
Race (%)							
White	80.0	100.0	85.7	100.0	100.0	100.0	92.3
Minority	20.0	0.0	14.3	0.0	0.0	0.0	7.7
Full-time (%)		28.6			16.7		23.1
Education Degree (%)							
Yes	40.0	100.0	57.1	40.0	0.0	33.3	46.2
Highest Degree (%)							
Bachelors	60.0	50.0	57.1	20.0	0.0	16.7	38.5
Masters	40.0	50.0	42.9	80.0	100.0	83.3	61.5
Hold Teacher Certification (%)	20.0	100.0	57.1	60.0	0.0	50.0	46.2

## **Students**

As revealed by the student questionnaire and student data records, the 179 students who participated in this study reflected varied demographics, as displayed in Table 4. The information is organized by treatment group, control group, and for all participating students for comparison. The treatment group and control group demographics are similar. All data in Table 4 are from the student records unless otherwise noted.



Table 4

*Student Demographic and Academic Background Information*

Characteristic	Treatment Group	Control Group	All Student Participants
<i>n</i> of Students	96	83	179
Female (%)	77.1	56.1	71.5
Race (%)			
White	47.9	45.8	46.9
Black/African American	36.5	44.6	40.2
Other	15.6	9.6	12.8
Age Average (years)	24.78	26.41	25.65
Age Maximum (years)	61	55	61
Repeated course at least once (%)	28.1	27.7	27.9
Mean number of semesters at cooperating community college (SD)	2.93 (2.27)	2.52 (1.43)	2.74 (1.93)
Reading Placement <sup>a</sup> mean (SD)	76.95 (12.67)	76.97 (14.53)	76.96 (13.51)
Student Tested into Developmental Reading (%)	39.4	32.0	36.1
Prealgebra Placement Score mean <sup>b</sup> (SD)	33.08 (7.75)	32.48 (9.05)	32.79 (8.38)
English Placement Score mean <sup>c</sup> (SD)	58.34 (27.11)	63.81 (29.25)	66.61 (28.15)
Student did previously attend other post-secondary school <sup>d,f</sup> (%)	79.5	76.9	78.2
Last high school mathematics course <sup>e,f</sup> (%)			
Prealgebra or General Mathematics	19.8	16.9	18.4
Algebra/Algebra 1	6.3	10.8	8.4
Algebra & Geometry	26.0	33.7	29.6
Algebra 2, Trigonometry, Precalculus, or Calculus	27.1	27.7	27.4

*Note.* *n* = 179 unless otherwise noted.

<sup>a</sup>*n*=161, treatment *n* = 87, control *n* = 74

<sup>b</sup>*n*=170, treatment *n* = 89, control *n* = 81

<sup>c</sup>*n*=162, treatment *n* = 86, control *n* = 76

<sup>d</sup>*n*=156, treatment *n* = 78, control *n* = 78

<sup>e</sup>*n*=154, treatment *n* = 78, control *n* = 76

<sup>f</sup>Data from student questionnaire

### **Students' year of high school graduation and topic of last high school**

**mathematics course.** Student questionnaires were administered in order to collect background information regarding the sample of 179 students in the study; 156 (87%) of the participating students completed the questionnaire. This questionnaire secured data that provided a more detailed characterization of the mathematical background of the students in the sample by characterizing the title and timing of their last high school mathematics course. As indicated in Table 5, approximately 45% of those who returned the questionnaire graduated from high school 3 or more years earlier and approximately 54% were last in their high school mathematics course 3 or more years earlier. Indeed, students who had graduated from high school as early as 1973 were enrolled in this course. About 42% of the students who completed the questionnaire graduated from high school the year immediately prior to entering the college and approximately one-half of these students completed a mathematics course during their last year of high school. Slightly less than one-half of the participants completed their last mathematics course during their junior year of high school. Two years prior to enrolling in this developmental mathematics course, 13% of the students graduated from high school and likewise, approximately one-half of these students took a mathematics course during their senior year in high school.

Table 5

*Frequency of Last High School Mathematics Course by Year and Year of High School Graduation (percentage)*

Year of High School Graduation	Year of Last High School Mathematics Course			Total
	2009	2008	2007 and earlier	
2009	33 (21.4%)	27 (17.5%)	5 (3.2%)	65 (42.2%)
2008	0 (0%)	11 (7.1%)	9 (5.8%)	20 (13.0%)
2007 and earlier	0 (0%)	0 (0%)	69 (44.8%)	69 (44.8%)
Total	33 (21.4%)	38 (24.7%)	83 (53.9%)	154 (100.0%)

The topic of the last high school mathematics course completed by these students is shown in Table 6. Note that approximately three-quarters of the students had completed a high school mathematics course that was more advanced than the prealgebra developmental mathematics course in which they were currently enrolled. In addition, 21.4% of the students had already completed a mathematics course during high school that was nearly the same as the course in which they were enrolled in during the semester of the study.

Table 6

*Frequency of Last High School Mathematics Course*

Topic of Last High School Mathematics Course	Number of Students	Percentage of Students
Prealgebra & General Mathematics	33	21.4
Algebra or Algebra I	15	9.7
Algebra & Geometry	53	34.4
Algebra 2, Trigonometry, Precalculus, or Calculus	49	31.8
No Response	4	2.6
Total	154	100.0

**Students' program of study and mathematics requirements.** The cooperating community college supplied information from the student records identifying the program of study and intended degree for sampled students. Table 7 displays the distribution of students by degree type including credit requirements and program options. Furthermore, Table 8 shows the distribution of students in each program of study.

Table 7

*Distribution of Student Registration by Degree Type, Specifying Credit Requirements and Program Options*

Degree Type	Percentage of Students	Number of Credit Hours Required for Degree	Number of Programs Offered
Letter of Recognition (LOR)	0.6	6-11	32
Certificates of Proficiency	4.5	15-42	37
Associate of Applied Science (AAS)	16.2	60-70	29
Associate of Arts (AA)	41.9	60-64	31
Associate of Science (AS)	25.1	61-70	8
No degree pursued	11.8		

*Note.*  $n = 179$

Degree options at this community college move progressively from Letters of Recognition (LOR) to Certificates of Proficiency to Associate's Degrees. The degree options are progressive as courses presumed in the LOR may fulfill some certificate requirements; similarly required courses in the certificate option may fulfill some course expectations within associate's degree programs. No LOR program of study has a mathematics requirement. However, as indicated in Table 7, nearly 1% of the students in this sample were pursuing the degree option mathematics course, albeit a developmental course. These students may have intended to improve their basic mathematics skills or they may have been planning to pursue a certificate or associate's degree in the future. Most certificate programs do require a mathematics course, while all associate's degrees do require completion of at least one prescribed mathematics course. Typically, the differences between an Associate of Arts (AA), Associate of Science (AS), or an

Associate of Applied Science (AAS) degree are the number of general education course requirements. AA and AS degrees require at least 30-36 credit hours of general education courses, while AAS degrees require at least 20 credit hours of the same. The large percentage of students pursuing AA degrees may reflect the large variety of programs of study within that degree option.

Table 8:

*Distribution of Students by Program of Study*

Program of Study	Number of Students	Percentage of Students
Mathematics, Engineering, & Sciences	4	2.2
Industrial & Technical Studies	8	4.5
Communications, Arts, & Humanities	13	7.3
Business Studies	20	11.2
Health Sciences	48	26.8
General Studies	26	14.5
Human, Social, & Teacher Education	39	21.8
Non-degree	21	11.7
Total	179	100.0

The largest percentage of developmental mathematics students in the study, as shown in Table 8, are enrolled in programs of study associated with Health Sciences, which includes the popular major of nursing. The next largest percentage of students was enrolled in Human, Social, and Teacher Education programs. As might be expected, most of these developmental mathematics students were not enrolled in programs of

study spanning mathematics, engineering, and the sciences. These programs require multiple, advanced mathematics courses, and students placed in developmental mathematics are beginning with a severe deficient. Prior research indicates that students who begin the study of college mathematics via developmental mathematics courses are most likely not to finish that degree (Carey, 2004). Of the students enrolled in this study's sampled developmental mathematics course, 149 (83%) were pursuing an associate's degree. The terminating mathematics course for 116 of the students was College Mathematics, which requires a prerequisite algebra course. In other words, these students are required to complete at least two additional mathematics courses following this developmental mathematics course to fulfill the requirements of their degree. An additional 20 students' terminating course is College Algebra, requiring two prerequisite algebra courses. These students are required to complete at least three additional mathematics courses to fulfill the requirements for their degree. The remaining 12 students' terminating course is calculus or business calculus. To fulfill this degree requirement, these students will be required to complete at least four additional mathematics courses.

### **Instructional Approach**

#### **Control Instruction**

Instructors who agreed to participate but did not volunteer to incorporate content area reading strategies into their instructional practices provided the instructional staffing for the control group, teaching in their usual manner. The researcher attended class meetings in each of the control group sections to confirm that content area reading strategies were not being implemented. The researcher, out of consideration for the

instructors, coordinated class meeting visits with each instructor. Every control instructor was visited at least two times during the semester.

### **Treatment Instruction**

Prior to the study, a one-semester pilot study was conducted to inform the pacing and design of the delivery of the instructional reading strategy treatment. The pilot also permitted the researcher to evaluate how the proposed content area reading strategies were received by the instructors. The instructors provided constructive feedback addressing the use of and materials for each strategy; this feedback was used to modify the presentation of the strategies and to improve the instructional materials supporting their implementation.

Treatment instructors were expected to incorporate content area reading strategies into their instructional practices for the course. Content area reading strategies, materials, and implementation instructions were provided by the researcher. The reading strategies were designed to increase student interaction with the mathematics textbook and to support student learning in areas of mathematics that have been particularly problematic for developmental mathematics students. According to the course leader, the use of content area reading strategies for this purpose is a departure from normal instructional practices in this developmental mathematics course. Time requirements during class varied depending upon the content area reading strategy implemented. The reading strategies were designed to enhance the teaching of particularly problematic topics in developmental mathematics, not to add more instruction time. The instructional practices using the content area reading strategies were intended as a replacement of normal instructional practices for the portion of the class meeting targeted.



**Five reading strategy foci.** This study incorporated eight different content area reading strategies in 14 implementations. The eight reading strategies have various foci, however each strategy as designed for this study, has one main focus. These eight reading strategies are revealed to have predominantly five foci as shown in Table 9. The reading strategy foci were used to design specific content area reading strategies for this study: text features, self-evaluation, visual representation of text, conceptual understanding, and sequencing.

Instruction for *text features* can help students with “those aspects of text content and presentation that influence comprehension” (Barton & Heidema, 2002, p. 13). It includes drawing students’ attention to the table of contents, index, types of text (e.g., graphics, maps, pictures, illustrations, captions), sidebars and boxes, typography (e.g., large, bold type for chapter titles, smaller subheadings, bolded words, italics), color, symbols and icons, section/chapter organization, headers and footers, glossary, appendices, and section/chapter testing (Daniels & Zemelman, 2004; O’Connell & Croskey, 2008). Understanding the organization of a textbook can help students locate information and better understand the content.

*Metacognitive* strategies “provide a system for self-monitoring and self-correction of meaning construction during and after instruction” (Ruddel & Unrau, 2004, p. 1493). They may help students navigate their way through unfamiliar text by setting a purpose for reading the selection, activating prior knowledge, and developing language fluency, particularly the necessary academic language. Expert readers realize not all information in a reading is of equal importance and they know how to be selective while novice readers do not. It is recognized “that passive reading is not consistent with adequate

comprehension” and that students greatly improve their reading comprehension with guidance from their instructor (Hempenstall, 2004, p. 743). Students can learn to monitor their comprehension and note which fix-up strategies they employ such as re-reading and reading slower.

*Visual representations for text* are generally graphical tools for organizing and representing knowledge and may appear in many forms. Visual representations take many forms, for example graphic organizers, concept maps, matrices, concept webs, webbing, and mind maps. These instructional tools are designed to assist students to think about information in new ways and to focus on the connections among concepts. Furthermore, these tools visually represent relationships between ideas, notation, pictures, and words differently from the textbook’s presentation. Large amounts of information can be represented in a single picture which is excellent for visual learners. Graphic organizers are known to enhance recall, to clarify information, to assist in organizing thoughts, and to promote understanding. The use of visual representations for text “increases the odds that a student can find a format and medium that are accessible and useful....Even students for whom access is not a problem will benefit from the redundancy of mixed media and formats, which can foster deeper understanding” (Strangman, Hall, & Meyer, 2003, p. 13). The NRP asserts that use of “graphic organizers” is one of seven types of instruction shown to improve comprehension in non-impaired readers (NPR, 2001). “The main effect of graphic organizers appears to be on the improvement of the reader’s memory for the content that has been read” (NPR, 2001, p. 267).

*Conceptual understanding* is extremely important to reading and mathematics when a deep, profound understanding is desired. It has been suggested the students often feel like “outsiders” in subjects such as mathematics partially due to their unfamiliarity with the academic language; however, by demystifying this academic language, students may become “insiders” (Bravo & Cervetti, 2008). New vocabulary is often indicative of the new content being taught. Students will rarely be successful in understanding the concepts of mathematics without also understanding the academic language associated. Learning the language of mathematics is as important as learning the mathematics; “one can argue that words are, in fact, the surface level instantiations of the deeper underlying concepts and that, as such, they provide the connections to the everyday discourse that makes the concepts transparent” (Bravo & Cervetti, 2008, p. 131). These reading strategies can illustrate the semantic relationships among key concepts, namely, the vocabulary. Through a word sort, students classify words into categories based on their prior knowledge looking for shared features among the words’ meanings (Barton & Heidema, 2002). This strategy may also extend students’ understanding of concepts and their connections. Students need to consider the relationships among and between groups of words.

*Sequencing* refers to identifying components of a story such as the beginning, middle, and end and to possessing the ability to retell the events of a story in the order in which they occurred. It also provides students with the ability to examine text and story structure and to understand how and why to move from one element to another, to understand how the elements are organized and the importance of that order. Research

has shown that when students sequence text, their comprehension is deeper and their memory is “robust” (Therriault & Raney, 2002, p. 132).

The column headings in Table 9 show the five reading strategy foci, the specific content area reading strategies by title, the mathematics focus, the estimated time required in-class, the brief description, and any notes. Often, the amount of time required for each strategy to be implemented varied depending upon the number of provided discussion questions the instructor utilized and the amount of discussion the instructor encouraged. See Appendix D for samples of reading strategy instruments.

Table 9

*Content Area Reading Strategy Instructional Components*

<b>Strategy Focus</b>	<b>Strategy Title</b>	<b>Mathematics Focus</b>	<b>Class Time (minutes)</b>	<b>Brief Description</b>	<b>Notes</b>
Text Features	Get to Know Your Textbook	Mathematics textbooks are organized differently from textbooks in other content areas and novels.	20	Students work in groups to answer questions on a handout about the structure of their course textbook.	There is a handout to guide the students through parts of the textbook.
Metacognition	Independent Study Guide	Use of reading strategies may address the difficulties of reading and comprehending a mathematics textbook without the guidance of the instructor.	3	This is a take-home supplement only one of two independent study assignments. It provides a guide for reading through the assigned sections with questions to be answered.	There are two Independent Study assignments during the semester but only one assignment is addressed in this study.
Metacognition	Self-evaluation	Reading a mathematics textbook requires students to monitor their comprehension as they read.	20	Students silently read a passage from the textbook and highlight the portions they understand well enough to explain to another student in pink, otherwise they highlight in yellow. Students will note the fix-up strategies used due to use of highlighters.	There is a one-page handout of a page from the textbook so students can use the highlighters and to note the approach they used when reading.
Visual Representation of Text	Fractions Decimals Percent	This strategy is designed to help students make a visual representation between fractions and decimals, decimals and percents, and fractions and percents.	15-25	Groups of students were given partially completed concept maps to complete for the first two implementations. The third was a blank labeled 3x3 array to be completed with all six conversions including examples of each.	This activity was implemented in three parts (converting from decimals to fractions, converting from fractions to decimals, and converting between fractions, decimals, and percents).

Visual Representation of Text	Word Problem Solving Guide	Comprehension of word problems is difficult for many community college students and often students do not know how to approach a word problem.	30-40	Instructors first use the guide to show students how to approach solving word problems. Students then work in groups solving word problems using the guide and complete one homework problem using the guide.	There are two Word Problem Strategy Guides during the semester.
Conceptual Understanding	Vocabulary	This strategy is designed to help students become aware that some vocabulary in mathematics have been “borrowed” and may or may not have the same meaning in everyday usage.	15-25	Students are given a table with four columns. First column has listed vocabulary words. Next two columns to be completed are everyday and mathematics definitions. Last column students are to compare the two types of definitions. The meanings may or may not be the same.	There is a handout out with vocabulary organized by chapter.
Conceptual Understanding	Word Sort	Designed to be a complete Unit review incorporating reading strategies to help students tie together procedures, concepts, and vocabulary.	25-50	Students are given a list of the vocabulary words and category topics from the Unit. Students sort the words into the categories. Once finished, each group will share their work as the instructor asks questions to connect vocabulary, concepts, and procedures.	This strategy was to be used for each of the three Unit reviews during the semester. This strategy included a kinetic activity.
Sequencing	Scrambled Solutions	This strategy is designed to help students read the steps of an equation solution and understand how mathematics procedures are organized and why, and what properties are used.	15-25	Groups of students are given a detailed listing of steps for a solution to an equation, but the steps are not in order. They are to re-order the steps constructing the solution of the equation and to explain what concept supports or justifies that step.	There were two Scrambled Solutions during the semester. Time required depended on the number scrambled solutions the instructors used. This strategy included a kinetic activity.

Treatment instructors did not receive professional development addressing use of the eight reading strategies prior to the initiation of the study semester. The researcher did meet with the instructors individually as their schedules allowed throughout the semester. Prior to instruction, instructors received all materials addressing implementation of the content area reading strategies. This included written explanations for the purpose of the strategy, hard copies of any handouts, keys for the handouts, discussion questions to deepen learning from each strategy and foster discussion, and implementation instructions. The implementation instructions also contained a script the instructors could use to frame instruction for each content area reading strategy. The script provided instructors with support and guidance for explaining the use of the reading strategy to the students. The intent was to increase each instructor's comfort with the purpose and implementation of the strategy. The implementation materials also provided the instructors with a list of discussion questions from which the instructors could choose questions to ask the students as part of the instruction utilizing each strategy. The rationale for the questions was to deepen comprehension and to strengthen the connections that the students could form due to use of a reading strategy. The discussion questions were included for each strategy in order to support and enhance the learning of the mathematics and to convey the intent that the strategy was not an add-on activity with little relation to the concepts of the mathematics being taught.

The researcher attended specific class meetings in each of the treatment sections to confirm that content area reading strategies were being implemented.

The researcher, out of consideration for the instructors, coordinated class meeting visits with each instructor. Every treatment instructor was visited at least four times during the semester.

### **Common Instructional Approaches across all Sections**

Students in this course had multiple assignments due for virtually every class meeting: computer tutoring system assignments, textbook homework, previews, as well as anything the individual instructor might have required. In addition, there were sufficient quizzes and examinations established to permit administration of one assessment to occur every week. The students found keeping multiple expectations difficult and confusing, frequently asking or needing to be reminded as to which assignments were due and when quizzes and examinations were scheduled. Numerous instructors, treatment and control, would write on the board what was due that day and what was scheduled for the next one or two class meetings.

Several instructors used warm-up problems, displayed on the board, for students to work on as soon as they entered the classroom. This was a common occurrence for the instructors who had K-12 teaching background. Additionally, several instructors held notes or used PowerPoint to organize their instruction as they conducted their lessons.

### **Data Analysis**

#### **Quantitative**

Data was collected for all participating students, both treatment and control sections. Descriptive statistics were used to describe the students and the



instructors for both the control and treatment groups and were used as sources for control measures during analyses. SPSS was used to analyze student and instructor demographic data and questionnaire data for descriptive purposes. Hierarchical linear modeling (HLM 7) was used to examine the individual student standardized mathematics course achievement differences across the two groups (control and treatment). Two final HLM models were established for the quantitative analysis. One used a continuous outcome variable for the students' average points earned on the quizzes, course examinations, and final examination combined and the other used a binary outcome variable for the passing or failing the course. Additionally, student data was analyzed using student characteristics such as race/ethnicity, age, gender, prealgebra placement score and reading placement score.

### **Qualitative**

Classroom observation field notes were taken in approximately 60 classroom sessions in both treatment and control classes during the semester at four different locations. The field notes were used to review the implementation of a reading strategy compared to the intended implementation as provided by the researcher. In the control sections, field notes were used to ensure that no reading strategies designed for the study were used. Additionally, the field notes were used to ensure that both groups, treatment and control, were providing comparable mathematics material and assessments as provided for in the syllabus.

The faculty interviews were conducted with all 13 participating instructors midway through the semester. A second interview was conducted with on the

treatment instructors at the end of the semester. Each interview was approximately 20 - 30 minutes in length and notes were taken by the researcher.

All field notes and interview notes were transcribed by the researcher and compiled to review the implementation of each reading strategy (e.g., vocabulary, scrambled solutions) across instructors. Additionally, field notes and interviews for each treatment instructor were used to analyze each instructor's implementation of the reading strategies across the semester.

## **Chapter 4 – Quantitative Analysis and Findings**

In this chapter, the results of the quantitative portion of the study are presented and analyzed. A total of 179 students and 13 faculty from 16 sections of a prealgebra developmental mathematics course at a community college participated. Of the students, 96 were in treatment sections, and 83 were in control sections. Of the faculty, seven were instructors of record in treatment sections, and six were instructors of record in control sections. The collected quantitative data consisted of course assessments via the students' quizzes, course examinations, and final examination scores. Further descriptive data were collected from students and faculty to aid this analysis. Analysis of the data yielded information that addressed the three research questions.

- Research Question 1: What is the impact of instruction incorporating content area reading strategies on the mathematics achievement of students in a community college, prealgebra, developmental mathematics course?
- Research Question 2: What, if any, demographic factors influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?
- Research Question 3: What, if any, prior educational background of the enrolled students influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?

This chapter is organized into three sections. The first section discusses the course assessments while the second section covers the hierarchical linear modeling analysis. The last section is a summary of the data for the three research questions.

### **Course Assessments**

The course point allocation came from several forms of assessment (see Table 2). Three of the assessment forms consisted of student scores for quizzes, course examinations, and a final examination which were standardized across all sections. Instructors were provided each quiz, course examination, and final examination as well as an answer key for each assessment. However, no grading rubric was provided or implied. Table 10 provides a comparison of means, using the independent-samples *t*-test, for select measures: average of the quizzes (best 6), average of the quizzes (all 7), average of course examinations, final examination, Utilized Course Points (consists of best 6 quizzes, course examinations, and final examination), and Total Course Points for the treatment and control groups. Additionally, the two prior knowledge measurements (prealgebra and reading placement tests) and student age were compared. Course policy did not allow make-up quizzes to be administered if a student was not in attendance on the day a quiz was administered. Although not encouraged, other arrangements could be made with the instructor if a student required an alternative date for a course examination or the final examination.

Table 10

*Independent Samples t-test for Selected Measurements Comparing the Treatment and Control Groups*

Measurement	<i>n</i>	M	SD	<i>t</i> -test (df)	<i>p</i>
Total Course Points					
Control	83	613.31	149.47	1.994 (177)	.048
Treatment	96	565.83	166.42		
Utilized Course Points <sup>a</sup>					
Control	83	0.14	0.92	1.764 (177)	.080
Treatment	96	-0.12	1.06		
Quiz Average (best 6)					
Control	83	11.14	2.45	1.992 (177)	.048
Treatment	96	10.35	2.81		
Quiz Average (all 7)					
Control	83	10.25	2.53	1.946 (177)	.053
Treatment	96	9.46	2.86		
Exam Average					
Control	83	55.51	14.84	1.242 (177)	.216
Treatment	96	52.70	15.30		
Final Examination					
Control	83	134.47	48.13	1.633 (177)	.104
Treatment	96	121.78	54.82		
Age					
Control	83	24.78	9.568	-1.098 (177)	.274
Treatment	96	26.41	10.11		
Prealgebra Placement Test <sup>a</sup>					
Control	81	-0.04	1.08	-0.463 (168)	.644
Treatment	89	0.03	0.93		
Reading Placement Test <sup>a</sup>					
Control	74	0.00	1.08	0.009 (159)	.993
Treatment	87	0.00	-0.94		

<sup>a</sup>Variable is standardized.

An independent-samples *t*-test was conducted to compare the treatment and control groups for the various measurements listed in Table 10. Type I error

standard ( $\alpha$ ) was set at .05. The measurement for the average of the best 6 of 7 quizzes did show a statistically significant difference between the treatment ( $M = 10.35$ ,  $SD = 2.81$ ) and control ( $M = 11.14$ ,  $SD = 2.45$ ) groups [ $t(177) = 1.992$ ,  $p = .048$ ]. However, when the average for all seven quizzes is reviewed, there is no statistical significance. Review of group means indicates that the course policy to drop the lowest quiz score may have advantaged the control group. The only other measurement to show a statistically significant difference was the Total Course Points favoring control [ $t(177) = 1.994$ ,  $p = .048$ ]. Yet when the Utilized Course Points is the outcome measure there is no statistically significant difference between the treatment and control groups. The assessments which compose the Utilized Course Points are the best 6 quizzes, course examinations, and the final examination which are common across all the sections. The remainder of the course point allocation was not standard across the sections as instructors had discretion to include other expectations or assignments.

The assessments which compose the Utilized Course Points are also included in the Total Course Points. The maximum number of Total Course Points available was 780 points, although some instructors did include extra credit at their own discretion as evidenced in Table 11 for Maximum Score under Total Course Points. This occurred for both, treatment (7 extra points) and control (8 extra points) groups. It is interesting to note that the treatment group achieved a higher minimum score than the control group as indicated by Utilized Course Points (a 2 point advantage) and by the Total Course Points (a 20 point advantage). This implies that the treatment instructors may have been more

generous when assigning points to assessments other than the Utilized Course Points' assessments. These other assessments (see Table 2) include, for example, notebook grades and practice assignments. Again, no rubrics were provided for evaluating other assessments, nor were practice assignments provided to the instructors. Practice assignments were completely at the discretion of the individual instructors. The 20 point advantage, albeit a small advantage, for the minimum score the treatment group held did not translate into a higher percentage of students in the treatment sections passing the course.

Table 11

*Descriptive Statistics for Utilized Course Points and Total Course Points*

	Treatment	Control	Combined
<i>n</i> of students	96	83	179
Utilized Course Points			
Mean	341.60	369.35	354.53
Standard deviation	111.53	96.80	105.58
Minimum Score	87	85	85
Maximum Score	479	483	483
Quartile 1	268.00	357.00	316.00
Quartile 2 (Median)	386.50	403.00	391.00
Quartile 3	424.00	434.00	427.00
Total Course Points			
Mean	565.84	613.31	587.85
Standard deviation	166.42	149.47	160.00
Minimum Score	173	153	153
Maximum Score	787	788	788
Quartile 1	474.25	561.00	524.00
Quartile 2 (Median)	627.00	659.00	636.00
Quartile 3	697.75	714.00	699.00
Course Outcome			
Passed Course (%)	63.54	68.67	65.92

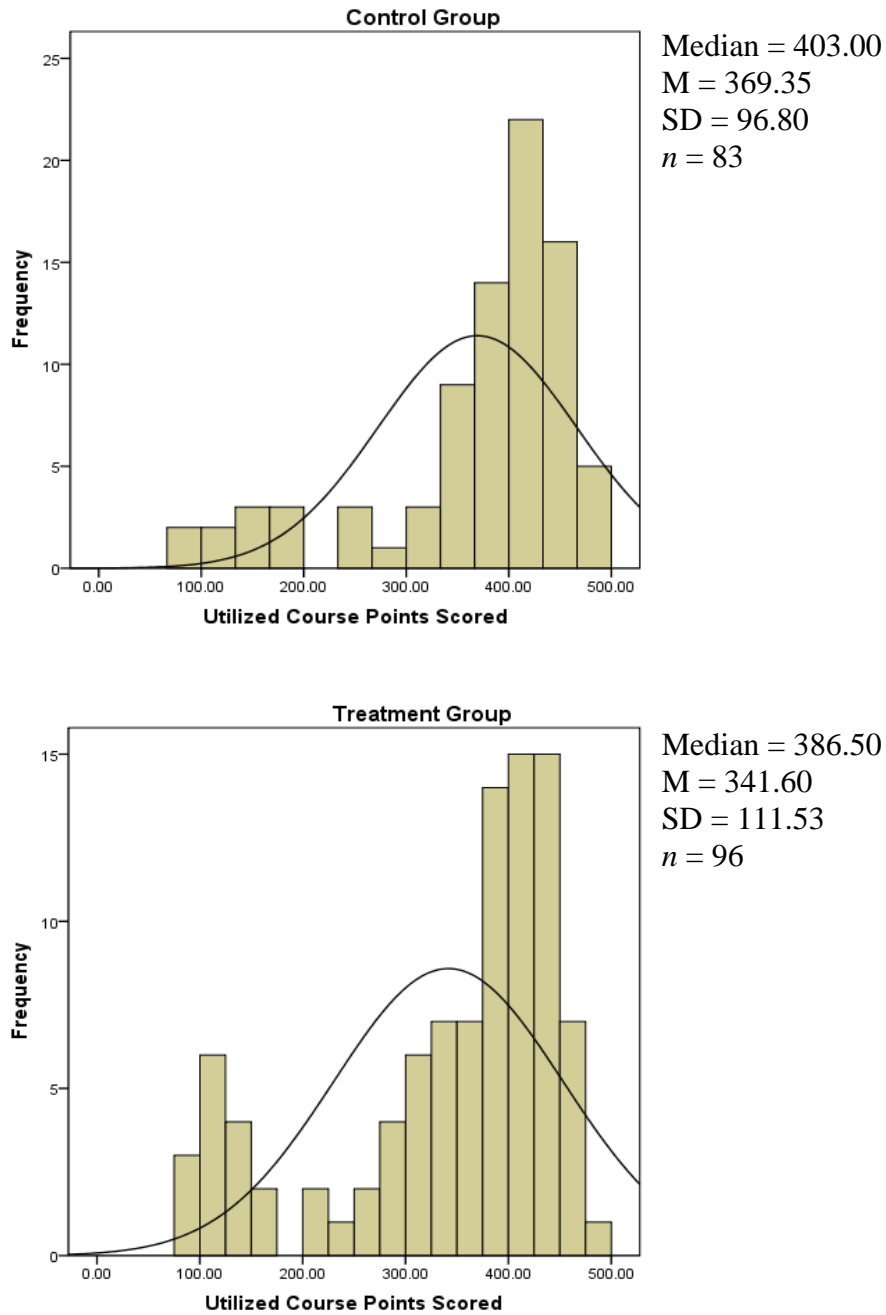
*Note.* A minimum of 80% (624 points) is required to pass the course. No students received a grade of IP.

It is notable that the mean and the median for each measurement in Table 11 were not relatively similar. The median, in each case, is a much larger value than the mean. This signifies that the extreme low values are farther away from the mean than the extreme high values. In other words, the students who performed extremely poorly in the course earned points much farther below the mean than students who earned course points above the mean. As seen in Figure



4, the histograms indicate that the median is much larger than the mean. The data are not normally distributed and are skewed to the left, a long tail of low scores. There is a natural boundary, to the right at 489 points, for the Utilized Course Points which can be earned. This occurred for treatment and control groups. The histogram for the treatment group indicates that more students within the treatment group were at the “lower end” of course achievement. Students were “placed” into the prealgebra developmental mathematics course because their performance on a standardized mathematics achievement measure fell with a prescribed boundary. Thus, as expected, this sample reflected a select prior achievement population represented by skewed data.

Figure 4



*Figure 4.* Histograms comparing the distribution of the Utilized Course Points scored by students within each group, Treatment and Control.

Review of the percentage of passing participating students within each section reveals a wide range (see Table 12). When comparing the data in terms

treatment and control sections, it is interesting to note the wide range of passing rates within each group. The lowest passing rate was 35.7% in a control section taught by an adjunct instructor, and the highest rate was 92.9% in a treatment section, also taught by an adjunct instructor. The range of the passing percentages for the treatment group was smaller than that of the control group. Though, both groups had a range from a low passing percentage of approximately 40% to a high of approximately 92%. There was approximately a 5 percentage point difference for the passing rate between the treatment group (63.5%) and the control group (68.7%).

Table 12

*Treatment/Control by Percentage of Students Passing with Instructor Status*

Section Status	<i>n</i> of students	Instructor Status	Passed (%)
Treatment	15	Adjunct	46.7
Treatment	7	Adjunct	57.1
Treatment	11	Full-time	54.5
Treatment	14	Adjunct	50.0
Treatment	6	Full-time	66.7
Treatment	10	Full-time	40.0
Treatment	14	Adjunct	92.9
Treatment	10	Full-time	90.0
Treatment	9	Adjunct	77.8
Total	96		63.5
Control	15	Full-time	60.0
Control	14	Adjunct	35.7
Control	13	Adjunct	69.2
Control	8	Adjunct	87.5
Control	6	Adjunct	50.0
Control	13	Adjunct	92.3
Control	14	Adjunct	85.7
Total	83		68.7

When the course sections are regrouped by instructor status, full-time or adjunct, the range of percentage passing for participating students was similar with a low of approximately 40% and a high of approximately 92% (see Table 13). However, when the overall passing percentage by instructor status is recalculated, the passing percentage of participating students was remarkably similar. Exactly 62.2% of participating students in sections taught by adjunct

instructors passed the course as compared to 61.5% of the students taught by full-time instructors. These data indicate that while there was a wide range of passing rates across the 16 sections, there did not seem to be a pattern related to either treatment/control or instructor status.

Table 13

*Instructor Status by Percentage of Students Passing with Treatment/Control Noted*

Instructor Status	Section Status	<i>n</i> of students	Passed (%)
Full-time	Treatment	11	54.5
Full-time	Treatment	6	66.7
Full-time	Treatment	10	40.0
Full-time	Treatment	10	90.0
Full-time	Control	15	60.0
Total		52	61.5
Adjunct	Control	14	35.7
Adjunct	Control	13	69.2
Adjunct	Control	8	87.5
Adjunct	Control	6	50.0
Adjunct	Control	13	92.3
Adjunct	Control	14	85.7
Adjunct	Treatment	15	46.7
Adjunct	Treatment	7	57.1
Adjunct	Treatment	14	92.9
Adjunct	Treatment	14	50.0
Adjunct	Treatment	9	77.8
Total		127	62.2

### **Hierarchical Linear Modeling (HLM)**

Quantitative data were collected from 179 students and 13 instructors in 16 sections of a prealgebra developmental mathematics course at a community college. This treatment-control study was designed to determine the impact of incorporating content area reading strategies into a developmental mathematics course. The statistical analyses were completed using hierarchical linear modeling software (HLM version 7). HLM was used to partition the total variance for the outcome variable into within- and between-section components. This analysis resulted in the creation of two HLM models. The two models differed in terms of their defined outcome variable. One model defined the outcome variable as Utilized Course Points (ZAVGPTTOT), a continuous and standardized measure. A decision to use the outcome variable Utilized Course Points instead of Total Course Points was made because this reflected use of the common measures of quizzes, course examinations, and course final examination across all sections and no other measures. As noted earlier, this data is skewed due to the students' performance on a standardized mathematics achievement measure for placement into the course. The second model used a dichotomous outcome variable (PASSED). Based on final course evaluations as provided by the instructors, students were placed into one of two outcome categories, Passed or Failed.

The descriptive statistics for each variable is detailed in Table 14. It is organized by outcome variables, student-level variables, and section-level variables. Recall that the Utilized Course Points is a standardized variable while

Passed is a dichotomous variable. At the student level, demographic data for gender, minority status, and age are dichotomous dummy variables while the prealgebra and reading placement scores variables are continuous and standardized. Two section-level variables were defined. Both variables, High and Low Implementation, are dichotomous dummy variables. The implementation of the treatment was categorized as either high fidelity of treatment, low fidelity of treatment, or control. To determine a level of implementation for the reading strategies, several elements were considered: explanation of the purpose for the strategy, explanation of the strategy's connection with the mathematics, clearly explained strategy directions, alignment with implementation directions in the researcher provided guide, and use of discussion questions. It is notable that the High Implementation instructors did not fully adhere to every element listed. High Implementation sections were measured against the combination of Low Implementation and Control sections. Low Implementation sections were measured against the combination of High Implementation and Control sections.

Table 14

*Descriptive Statistics*

Variables	<i>n</i>	Mean	SD	Min	Max
Outcome Variables					
Utilized Course Points <sup>a</sup>	179	0.00	1.00	-2.55	1.22
Passed	179	0.66	0.48	0.00	1.00
Students-level Variables					
Female	179	0.72	0.45	0.00	1.00
Minority	179	0.53	0.50	0.00	1.00
Age 20 and up	179	0.55	0.50	0.00	1.00
Prealgebra Placement Score <sup>a</sup>	179	0.00	1.00	-1.89	3.73
Reading Placement Score <sup>a</sup>	179	0.00	1.00	-4.07	1.63
Section-level Variables					
Low Implementation	16	0.19	0.40	0.00	1.00
High Implementation	16	0.38	0.50	0.00	1.00

<sup>a</sup>Variable is standardized.

To further provide complete information on all variables used in this study, Table 15 clarifies the variable labels, variable names, a description of each variable, and the type of data represented. The description distinguishes between the student-level variables that were a student demographic and the variables that were a measurement of student prior knowledge. Type of data additionally clarifies the coding for each dummy variable. Table 15 is organized by outcome variables, student-level variables, and section-level variables.



Table 15

*Variable Descriptions*

Variable Label	Variable Name	Description	Type of Data
Outcome Variables			
Utilized Course Points	ZAVGPTTOT	The average of the three examinations, the final examination, and the best 6 of 7 quizzes.	Standardized and continuous
Passed	PASSED	Dummy variable for passing or failing the course.	0 = Failed 1 = Passed
Student-level Variables			
Female	FEMALE	A student demographic variable: a dummy variable for gender	0 = Male, 1 = Female
Minority	MINORITY	A student demographic variable: dummy variable with African Americans/Blacks, Hispanics, and Other as one group	0 = White 1 = All Others
Age 20 and up	AGE20UP	A student demographic variable: dummy variable for age	0 = ages 18 and 19 1 = ages 20 and up
PreAlgebra Placement Score	ZPREALG_	A student prior knowledge measurement: mathematics placement score	Standardized and continuous
Reading Placement Score	ZREAD_M	A student prior knowledge measurement: reading placement score	Standardized and continuous
Section-level Variables			
High Implementation	HITREAT	Treatment sections which were determined to be highly implement the reading strategies	0 = low implementation and control sections 1 = high implementation
Low Implementation	LOTREAT	The treatment sections which were determined to poorly implement the reading strategies	0 = high implementation and control sections 1 = low implementation

A collinearity diagnostic using SPSS was conducted to determine if multicollinearity would be an issue for the variables in this study. Tolerance is the diagnostic tool used to assess the possibility of multicollinearity; results are exhibited in Table 16. Generally, if the tolerance is above a value of 0.200 then there is a very low possibility of multicollinearity. Every value is above 0.800, therefore multicollinearity is not a concern. To further ensure that multicollinearity was not an issue, the Pearson's Correlation between the two placement scores was determined (see Table 17). It was low ( $r = 0.137$ ) and not statistically significant.

Table 16

*Multicollinearity Diagnostic for Student-level Variables*

Variable	Tolerance
Minority	.950
Female	.972
Age 20 and up	.920
PreAlgebra Placement Score	.967
Reading Placement Score	.851

Table 17

*Correlations of Student-level Variables*

Variables	Reading Placement Score	Prealgebra Placement Score	Female	Age 20 and up	Minority
Reading Placement Score	1	.137	.136	.262**	-.210**
Prealgebra Placement Score		1	-.034	-.049	-.085
Female			1	-.020	.026
Age 20 and up				1	-.035
Minority					1

\*\*  $p = .01$ **HLM Model with Continuous Outcome Variable**

**Fully unconditional model.** A fully unconditional model was created to review the reliability and the intra-correlation coefficient (ICC) for the outcome variable. Table 18 provides the details of this model. The equation for a section-level fully unconditional model (no predictors are included) is specified by:

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

This model is an unbalanced, one-way, random-effects analysis of variance, in

which section is a random factor with varying numbers of students per section.

The within-section variance ( $\sigma^2$ ) is pooled across sections was estimated as 0.844

and the between-section variance ( $\tau_{00}$ ) as 0.175. Thus the ICC, the proportion of

total variance between sections is calculated to be 0.171. This indicates that 17%

of the variance in the Total Course Points occurs between the sections. The

reliability estimate ( $\lambda$ ) of the outcome variable, Total Course Points, was 0.657.

Table 18

*Fully Unconditional Model with Continuous Outcome Variable*

Estimated Effects				
Fixed Effect	Coefficients	Standard Error	Approx. d.f.	<i>p</i>
Average Section Achievement – Utilized Course Points, $\gamma_{00}$	-0.019	0.129	15	.883
Random Effect	Standard Deviation	Variance Component	d.f.	<i>p</i>
Average Section Achievement – Utilized Course Points, $u_{0j}$	0.418	0.175	15	<.001
Level 1, <i>r</i>	0.919	0.844		

**Final model.** The results of the final model with the continuous outcome variable are shown in Table 19. It has a reliability ( $\lambda$ ) of 0.503. The final model is specified by the following equation:

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Age) + \beta_{2j}(Female) + \beta_{3j}(PreAlgebra) + \beta_{4j}(Reading) + \beta_{5j}(Minority) + r_{ij}$$

The between-section model equations are specified by:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(LowImplementation) + \gamma_{02}(HighImplementation) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

Table 19

*Final Model with Continuous Outcome Variable*

Estimated Effects				
Fixed Effect	Coefficient	Standard Error	Approx. d.f.	<i>p</i>
Average Section Achievement – Utilized Course Points, $\gamma_{00}$	0.120	0.149	13	.433
Low Implementation, $\gamma_{01}$	-0.497	0.266	13	.085
High Implementation, $\gamma_{02}$	-0.120	0.226	13	.604
Prealgebra Placement Score, $\gamma_{10}$	0.245	0.074	139	.001
Reading Placement Score, $\gamma_{20}$	0.207	0.076	139	.007
Minority, $\gamma_{30}$	-0.295	0.144	139	.042
Age is 20+, $\gamma_{40}$	0.005	0.149	139	.973
Female, $\gamma_{50}$	0.342	0.157	139	.031
Random Effect	Standard-Deviation	Variance Component	d.f.	<i>p</i>
Average Section Achievement – Utilized Course Points, $u_{0j}$	0.279	0.078	13	.016
Level-1, $r_{ij}$	0.851	0.723		

The estimated effects identified for the final model using a continuous dependent variable is shown in Table 19. The average section achievement for the Utilized Course Points is 0.120. This represents the referent group of White males, age 18 to 19, with average scores on both the reading and prealgebra

placement tests. The impact of Low Implementation of reading strategies indicates a reduction in average course achievement when students' prealgebra and reading placement scores, race, gender, and age are controlled for. Low Implementation was statistically significant at the  $\alpha = 0.10$  level ( $p = .085$ ). Poor implementation of the reading strategies reduced average course achievement by approximately one-half of a standard deviation compared to control sections. However, even though High implementation was not statistically significant, it is indicative that it too also reduced the average course achievement, but only by approximately one-tenth of a standard deviation.

Overall, student demographics, with the exception of Age, were found to have an impact on the average course achievement. There was a statistically significant difference in achievement associated with minority race/ethnicity status (effect size  $-0.295$ ,  $p = .042$ ). This indicates that in Utilized Course Points the average difference between White and minority students is approximately  $0.295$  of a standard deviation. Thus, that on average the minority students' Utilized Course Points were about one-third of a standard deviation less than those of White students, controlling for other factors in the model. The average gender gap was also statistically significant (effect size  $0.342$ ,  $p = .031$ ). This indicates that in Utilized Course Points the average difference between male and female students is approximately  $0.342$  of a standard deviation. Female students, on average, performed approximately one-third standard deviation better than their male counterparts as measured by Utilized Course Points after controlling

for age, minority status, and placement test scores. Student age had no bearing on course achievement as measured by Utilized Course Points.

Student prior knowledge did impact average course achievement. Both the prealgebra and reading placement scores were statistically significant (prealgebra:  $p = .001$ ; reading  $p = .007$ ). On average, each single standard deviation increase on the prealgebra placement test reflected approximately a one-fourth of a standard deviation increase on the average earned Utilized Course Points after controlling for age, gender, minority status, and the reading placement test score. Similarly for every one standard deviation increase in the reading placement test score, the Utilized Course Points increased by approximately one-fifth of a standard deviation after controlling for age, gender, minority status, and prealgebra placement test score.

### **HLM Model with Dichotomous Outcome Variable**

**Fully unconditional model.** The fully unconditional model was created to review the reliability. The reliability ( $\lambda$ ) is 0.471. Table 20 provides the details of this model.

The equation for the student-level fully unconditional model is specified by:

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

Table 20

*Fully Unconditional Model for Dichotomous Outcome Variable*

Estimated Effects				
Fixed Effect	Odds Ratio	Standard Error	Approx. d.f.	<i>p</i>
Average Section Achievement - Passed, $\gamma_{00}$	1.83	0.237	15	.022
Random Effect	Standard deviation	Variance Component	d.f.	<i>p</i>
Average Section Achievement - Passed, $u_{0j}$	0.659	0.434	15	.016

*Note:* An ICC is not reported for a dichotomous outcome because there is not a true within group variance.

For a section with a “typical” pass rate the odds ratio is 1.83. The odds of passing the course are nearly twice the odds of failing the course. This is reasonable since roughly two thirds of the students passed the course.

**Final Model.** For the final model using the dichotomous outcome variable the results from the Population-Average Model is shown in Table 21.

The reliability was 0.392. The section-level equation is specified by:

$$\eta_{ij} = \beta_{0j} + \beta_{1j}(Age) + \beta_{2j}(Female) + \beta_{3j}(PreAlgebra) + \beta_{4j}(Reading) + \beta_{5j}(Minority) + r_{ij}$$

The between-section model equations are specified by:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(LowImplementation) + \gamma_{02}(HighImplementation) + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$



Table 21

*Final Model with Dichotomous Outcome Variable*

Estimated Effects				
Fixed Effect	Odds Ratio	Standard Error	Approx. d.f.	<i>p</i>
Average Section Achievement - Passed, $\gamma_{00}$	2.671	0.406	13	.031
Low Implementation, $\gamma_{01}$	0.523	0.682	13	.360
High Implementation, $\gamma_{02}$	0.922	0.613	13	.897
Prealgebra Placement Score, $\gamma_{10}$	1.846	0.250	139	.015
Reading Placement Score, $\gamma_{20}$	2.639	0.246	139	<.001
Minority, $\gamma_{30}$	0.509	0.409	139	.101
Age is 20+ $\gamma_{40}$	1.389	0.436	139	.453
Female, $\gamma_{50}$	2.755	0.437	139	.022
Random Effect	Standard deviation	Variance Component	d.f.	<i>p</i>
Average Section Achievement - Passed, $u_{0j}$	0.662	0.438	13	.069

For a section with a “typical” pass rate, the odds ratio is 2.671. The odds of passing the course are nearly three times the odds of failing the course. Both Low and High Implementation of the reading strategies treatment resulted in a reduction in the odds of passing the course, although neither was statistically significant. When the implementation quality was low, students had approximately half the odds of passing the course compared to failing the course. High quality implementation resulted in approximately the same odds of a student

passing the course as failing it. This relationship between Low Implementation and High Implementation mirrors the results found in the final model with the continuous outcome variable.

The only student demographic factor found to be statistically significant was gender. Female students were nearly 3 times more likely to pass the course than males after controlling for the other demographic factors and the placement scores. Neither age nor minority status were significantly associated with passing the course.

Student prior knowledge was shown to impact passing or failing the course. Both the prealgebra and the reading placement scores were statistically significant (prealgebra: odds ratio = 1.846,  $p = .015$ ; reading: odds ratio = 2.639,  $p < .001$ ). Thus the odds of passing the course were almost twice as high for students scoring one standard deviation above the mean on the prealgebra placement test as compared to the odds for students with average prealgebra placement test scores achievement after controlling for age, gender, minority status, and reading placement test score. Similarly, students who scored one standard deviation above the mean on the reading placement test were nearly 3 times more likely to pass the course than a student who scored at the mean on the reading placement test after controlling for age, gender, minority status, and prealgebra placement test score.

## Findings by Research Questions

**Research Question 1:** What is the impact of instruction incorporating content area reading strategies on the mathematics achievement of students in a community college, prealgebra, developmental mathematics course?

Two HLM models were developed to address this question. Both looked at the same outcome but with different measurements. One measurement was a standardized, continuous outcome variable measuring the average of the 6 of 7 best quizzes, 3 course examinations, and the final examination. The other measurement was a dichotomous dummy variable for passing or failing the course. The implementation of the treatment was categorized into high fidelity of treatment, low fidelity of treatment, and control. High Implementation was measured against the combination of Low Implementation and control. Low implementation was measured against the combination of High Implementation and control.

Overall, implementation of the reading strategies was not advantageous to the students for improving their understanding of the mathematics. In the continuous outcome final model, Low Implementation was found to be a statistically significant factor, but High Implementation was not. In the dichotomous outcome final model, neither level of treatment implementation was found to be statistically significant; however there were two patterns which occurred in both models. First, Low Implementation, in each model, had the lower  $p$ -value. Second, the coefficient for Low Implementation was always a smaller number than that of High Implementation. This implies that poor

implementation of the reading strategies may have distracted from students learning the mathematics, however, the High Implementation treatment was no worse or better than no reading strategies at all.

**Research Question 2:** What, if any, demographic factors influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?

The student demographics in the model were gender, age, and minority status. Again, these two models had similar results. Both models found a statistically significant effect associated with females' performance in the course. In both models females performed considerably better than male students in the course after controlling for age, minority status, and the placement tests scores. Minority status was statistically significant in the continuous outcome model ( $p = .042$ ) but not in the dichotomous outcome model ( $p = .101$ ). This indicates that there was not an interaction between race and treatment status. There was a statistically significant negative relationship between students' minority status and Utilized Course Points measuring course achievement but this did not persist when the outcome of interest was Pass/Fail status. Finally, in both models, age had little bearing on how a student performed in the course.

**Research Question 3:** What, if any, prior educational background of the enrolled students influence the impact of instruction incorporating content area reading strategies in a community college, prealgebra, developmental mathematics course?

Student prior knowledge was measured by student placement test scores for prealgebra and reading. Both prior knowledge measurements proved to be statistically significant in both models. In the continuous outcome model, both measures of prior knowledge influenced student achievement in the course by as much as one-fourth of a standard deviation for prior mathematics knowledge to one-fifth of a standard deviation for reading facility. It is interesting that performance on the reading placement test seemed to have a similar positive impact on the outcome in the prealgebra developmental mathematics course as did prior prealgebra knowledge.

## **Chapter 5 – Qualitative Analysis and Findings**

In addition to the quantitative data collected and analyzed within the control-treatment design, this study collected qualitative data in the form of interviews of the instructors and classroom observations. All instructors were interviewed mid-way through the semester and, in addition, the treatment instructors were interviewed at the end of the semester. These instructor interviews were conducted in order to characterize the thoughts and attitudes of the instructors toward developmental mathematics and toward the students who enroll in these courses. The additional interviews with the treatment instructors were conducted to explore their thoughts and attitudes toward the content area reading strategies that they were asked to implement. In addition, multiple classroom observations were conducted by the researcher in all sections. The classroom observations were conducted to verify the implementation of the reading strategies in the treatment sections although no criteria were used to address the quality of implementation. The classroom observations of the control sections were conducted to ensure that reading strategies were not being implemented and to ensure that the mathematics content and instructional design were comparable to that in the treatment sections.

### **Instructor Perspectives of Developmental Mathematics Courses and Students**

Each of the 13 instructors, both treatment and control, were interviewed by the researcher. The purpose of this 20-30 minute interview was to explore the instructors' perspectives regarding the developmental mathematics courses, this specific prealgebra developmental mathematics course, and developmental

mathematics students in general. Each instructor was sent the six interview questions a few days prior to her<sup>7</sup> interview (See Appendix C for faculty interview questions).

Instructors were asked how they had come to be teaching a prealgebra developmental mathematics course. Only one instructor purposely sought this course and its prerequisite course as this adjunct instructor preferred to teach these basic mathematics courses. Although the other instructors did not report purposely seeking to teach this course, most of them said they enjoyed teaching it and had often chosen to teach it since first teaching the course. The main reasons instructors gave for teaching this course were the numerous sections, locations, times, and days associated with scheduling this course, allowing maximum flexibility with other instructional assignments. Teaching this course, for these instructors, predominantly was a matter of convenience for scheduling. Only the course leader was required to teach a full load of developmental mathematics courses. Interestingly, less than one-half of the instructors reported ever teaching the prerequisite course for this prealgebra course.

When asked why or whether community colleges should offer developmental mathematics courses the instructors remarked that they realized community colleges offered second chances for students, whether due to the fact that a student may not have learned the material earlier or the student was returning to formal schooling after many years of absence. The instructors felt that developmental mathematics courses offered students the opportunity to build a solid foundation upon which to continue their education, as either a refresher

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<sup>7</sup> All instructors are referred to as female to further protect their privacy.

course or a course addressing gaps in prior knowledge. Some of the instructors (5 out of 13) believed that developmental mathematics courses offered students the experience of a college course while at the same time not actually delivering college-level mathematics content. Fewer instructors (4 out of 13) hoped the experience would help students make the transition to mathematics courses addressing college-level mathematics content. Two instructors stated that one purpose of developmental mathematics courses was to build students' self-confidence, sense of accomplishment, and self-esteem.

When asked about their experience teaching developmental mathematics courses or teaching this semester's course specifically, two perspectives were predominantly used by instructors: *frustration* and *positive* experience. The term *frustration* was used to describe several aspects of the course. Many instructors disliked the course's design and use of technology, specifically the use of computer software, but not the calculator. These instructors felt that the use of the computer added another layer of unfamiliarity and confusion for many of the students, mainly when the software did not work properly. This was viewed as being particularly difficult for the older returning students. A common complaint was that the software would often only accept answers in one representation although other representations were also correct. Additionally, the software would not notify the student that the representation was the issue, just that the answer input was incorrect. Other aspects that caused frustration for the instructors were students' lack of maturity, lack of prior mathematical knowledge, and students' sense of entitlement to a passing grade due to attending class. Three



instructors, each with many years' experience teaching K-12, specifically indicated that a year or more of delay in mathematics study, particularly for the traditional college-age freshmen who had not enrolled in a mathematics course during their senior year of high school, caused many problems for both the instructors and the students.

When the term *positive* experience was used to describe the developmental mathematics course, it was most often portraying experiences with older students who were nontraditional-age college students, as well as any students who were willing to learn. The older students were described by the instructors as being willing to do whatever they needed to pass the course including asking questions, seeking help from tutors and the instructor, and putting together study groups despite a lack of self-confidence. The instructors often distinguished between the older students and the younger students in terms of their willingness to ask for help and to talk with the instructor. A few of the instructors stated they liked the variety of students' ages and that the differences across and within every semester and every class of students appealed to them.

The instructors were also asked what they saw as the strengths and weaknesses of their developmental mathematics students. The strengths cited for students often mirrored why an instructor felt positive about teaching a developmental mathematics course. Identified student strengths included the desire to be in the class and learn, intrinsic motivation, willingness to help others, sense of humor, regular class attendance, willingness to ask questions, possession of a work ethic, and willingness to work in spite of a lack of confidence or prior

knowledge. The instructors thought that the fact that many of the older students were more motivated to pass the course was a benefit of their inherent maturity. One instructor thought that some students' strength was their "schmooze-ability."

Student weaknesses cited by the instructors focused on their lack of prior knowledge for the course, inability or unwillingness to place the course as a priority, lack of maturity, and lack of study skills. Particular prior knowledge deficits included reliance on the calculator because of poor understanding of basic operations and conversions (e.g., converting decimals to fractions), weak problem-solving skills particularly for word problems, and poor reading comprehension. Instructors noted the many excuses students gave for not making the course a priority. Work and family were mentioned by the instructors as the most frequent excuses given by the students. It was not the occasional demand to work overtime or to attend to unexpected childcare or child-illness issues that disheartened the instructors; it was the consistency throughout the semester for these types of excuses to be used by some students. The instructors thought that these students should not enroll in the course until they were able to make it a priority in their lives.

Throughout the interviews, every instructor mentioned the lack of maturity and the lack of study skills demonstrated by the majority of the developmental mathematics students. When questioned as to their lack of maturity, the instructors most often described examples that manifested as a lack of study skills on the part of students. Instructors listed numerous behaviors associated with deficient study skills: a lack of time management, a lack of consistency overall,

inconsistently attending class, a lack of effort, inability to follow directions, not knowing how to study, coming to class unprepared (e.g., forgetting calculator, textbook, or pencils), not keeping up with class, being unable to organize work, and not seeking help,

When asked what was rewarding about teaching developmental mathematics courses, the instructors specified several rewarding dimensions. The aspect mentioned by virtually every instructor was seeing students succeed in some way. More specifically, the rewards were seeing the “light-bulb” turn on for a student when that student finally understood something, seeing their students succeed in the next mathematics course, seeing prior students graduate, being thanked by their students, being asked by students if the instructor would be teaching the next mathematics course, and seeing students’ confidence increase. One instructor found that friendships were developed with students and that when these persisted after the course ended, it was rewarding. One adjunct instructor found teaching so rewarding, that she is considering a future full-time teaching career at the college-level.

As rewarding as the instructors found teaching this level of mathematics content and students, they also identified many challenges. These challenges frequently mirrored the weaknesses the instructors listed earlier. However, additional challenges noted were disrespectful students, and poor and or lazy attitudes on the part of students. The adjunct instructor who is considering a career change to full-time teaching stated that the challenge was figuring out what level to teach the material and how to teach and act.

Overall, from the interview, one recurring theme identified by every instructor revolved around the lack of study skills exhibited by the students. Another persistent comment was that virtually every instructor distinguished between the younger students and the older students. They found the older students to be more successful and “better” students because of their motivation and maturity.

### **Classroom Observations: Control Sections**

Each control section was observed twice to determine if any content area reading strategies were used, particularly the reading strategies designed for use in the treatment sections. The only reading strategy observed was mnemonics, which was not a reading strategy designed for the treatment phase of the study. The main mnemonic used was PEMDAS (Parenthesis, Exponents, Multiplication, Division, Addition, Subtraction) for order of operations. This was expected as the textbook devotes half of one page to describing this mnemonic after introducing order of operations. Several observations of treatment classes also included the use of this mnemonic. Two control instructors, both with many years of K-12 teaching experience, used two other mnemonics. One was KFC for *keep, flip, change* for the addition or subtraction of signed numbers. The other mnemonic helped students with division using the value of zero. While computing, the division of zero by a quantity is defined ( $0/k$  is OKay) but division of a quantity by zero is not defined ( $k/0$  is a Knock-Out).

Each of the control instructors actively pointed out vocabulary although no specific reading strategy for vocabulary was used. Most instruction for

vocabulary focused only on the definition. Instruction on the alternate definition that may cause confusion was not offered during the observations. Vocabulary instruction by the instructors was given orally.

### **Implementation of Reading Strategies**

The second interview was conducted with the seven treatment instructors at the end of the semester to address their perspectives regarding the content area reading strategies and their implementation. The interview questions were sent to each instructor a few days before her interview (See Appendix C for faculty interview questions).

During the spring semester in the mid-Atlantic region, there was severe winter weather, and the college closed several times including one full week. Most of the instructors spoke of how this disrupted not only their implementation of the reading strategies, but also the teaching of the course in general. Two of the instructors spoke about how they never felt they were able to get back on track for the semester, especially after the full-week closing.

Overall the instructors had a favorable impression of the content area reading strategies and, while they found it challenging to change their normal teaching style to implement the reading strategies, only two instructors mentioned that the time needed for implementation was a demand. The instructors were pleasantly surprised that the students seemed to enjoy the reading strategies and were willing to participate. Another pleasant surprise cited by the instructors was the fact that the strategies seemed to help some students better understand a topic and seemed to facilitate interaction among the students, while being less

threatening. Two instructors noted that the reading strategies also helped improve their own understanding of the mathematics material.

In the course of the interview, the instructors were asked which reading strategy was their favorite and least favorite, as well as their perception of the students' favorite strategies and which strategy that they felt was most effective in terms of helping students and least effective in terms of helping students. When responding they were allowed to name more than one strategy. Every instructor only named one or two strategies for each of these questions except for one instructor who named three favorite strategies. Recall that this study used eight unique strategies in 14 implementations. Therefore it was interesting to find that two strategies, word sort and scrambled solutions, were mentioned most often by the instructors. These two strategies were cited as answers for each of the interview questions. The next most frequently mentioned strategy was the guide for solving word problems, which was cited as an answer for all but one of the interview questions. It was not referenced when the instructors were asked to name a strategy that they felt was least effective for helping students.

The word sort, the scrambled solutions, and the guide for solving word problems were strategies that were implemented more than once during the semester. Word sort was implemented three times as it was designed to serve as a review strategy prior to each of the three course examinations; the other two strategies were each implemented twice over the course of the semester. It is not known if the instructors referred to these strategies in the interviews because they would have had more opportunity to work with them. The strategies involving

scrambled solutions and the word problem solving guide were more focused on mathematics techniques or understandings and therefore the instructors might have more readily inferred the impact of their usage on quizzes and examinations.

Table 22 presents the number of times a strategy was named in response to an interview question. Reading strategies that were never given as a response for any interview question are not included in Table 22. It is interesting to note that the strategies of scrambled solutions and word sort were most often given as answers by the instructors to the interview questions. The results of each interview question are further discussed below.

Table 22

*Number of Times a Reading Strategy is Given as an Answer by Interview Question Focus*

Strategy Name	Interview Question Focus					Total
	Faculty Favorite	Faculty Perceived				
		Faculty Least Favorite	Student Favorite	Most Effective	Least Effective	
Word Sort	2	4	2	2	4	14
Scrambled Solutions	4	3	3	2	1	13
Word-problem solving Guide	1	0	4	2	1	8
Concept Maps	2	1	1	0	1	5
Vocabulary	1	0	1	1	0	3
Self-evaluation	1	0	0	0	0	1
Total	11	8	11	7	7	44

**Faculty favorite reading strategies.** When the instructors were asked if they had one or more favorite content area reading strategies, three of the instructors chose more than one. The strategy of scrambled solutions was chosen by four instructors as a favorite, while word sort and concept maps were chosen by two instructors. The remaining strategies in Table 22 were each chosen only once and by different instructors. The four instructors who chose the strategy of scrambled solutions as a favorite thought that the cards, containing the solution steps for each problem, made it interesting for the students and that the strategy forced the students to think about the concepts associated with the procedures. Two of the four instructors modified their use of this strategy as they felt the original equation should have been identified for the students, therefore they did so. The two instructors who chose word sort as their favorite strategy thought that it helped the students associate concepts and provided students with a broader view of the material. The two instructors who referred to the strategy of concept maps as being their favorite, specifically favored Concept Map 3 which was the labeled 3x3 matrix which focused on all the percent-decimal-fraction conversions.

**Faculty least favorite reading strategies.** The faculty's least favorite strategies as measured by the instructors was either word sort or scrambled solutions, as four instructors disliked the first and three instructors disliked the latter (see Table 22). One instructor chose the concept maps as her least favorite strategy due to the implementation occurring near the end of the semester and she did not like that Concept Map 1 and 2 could be done at home by the students. The reasons given for disliking the strategy of word sort was that there were too



many words and that placement into categories was not straight forward and non-overlapping, as words could have been placed into more than one category depending upon the student's perception. The instructors did not recognize that this was intended by the researcher. One of the instructors disliked the amount of time that the use of word sort required. This instructor wanted to conduct her normal review lesson for the examination and saw sorting words as an extraneous, unrelated task. The intent was for this reading strategy to serve as the complete review, replacing any other review strategy. Another instructor stated that the students needed too much prodding when completing a word sort and could not make the connections on their own; therefore she felt she needed to make the connections for the students. In terms of scrambled solutions, one concern leading to its designation as least preferred was that the original equation was not highlighted for the students, a comment also given by two instructors who had chosen this strategy as their favorite.

Interestingly, the strategy of scrambled solutions was the only strategy that each instructor chose as either a favorite or a least favorite strategy. The scrambling of the solution steps was thought to be too confusing for students, and one instructor thought it was difficult to get students to verbalize the reasoning supporting their work. The word sort was chosen by six of the seven instructors as either a favorite or a least favorite strategy. It seemed that each of these two strategies either "fit" an instructor's normal instructional practice or it did not.

**Faculty perception of students' favorite strategies.** When asked which strategy they perceived as being most enjoyed by their students, the answers were

varied. One instructor listed three reading strategies, three instructors listed two strategies; the remaining three instructors listed only one strategy each. The strategy most often listed was the word-problem solving guide (4), next was scrambled solutions (3), and followed by the word sort (2). The strategies of vocabulary and concept maps were each cited only once by single instructors (see Table 22). Two instructors thought the students liked the word-problem solving guide as it was better than Polya's four-step process for solving word problems given in the textbook, helped with homework, and it helped to remove "some of the paralysis students can feel when faced with word problems." One instructor reported that her students really liked the word sort category for "Math Instructions." Overall, the instructors cited two reasons for their choices. First, they thought the students liked a strategy best when the instructor liked the strategy. Second, they thought the students responded well to the group work and to the strategies that had a kinetic aspect such as moving cards around (e.g., scrambled solutions, word sort).

**Faculty perception of the most effective and the least effective strategies.** The instructors were asked which strategies they thought were most effective in terms of helping the students learn the material and which were least effective. Each instructor only chose one strategy in answer to each of these two questions (see Table 22). Word sort was chosen by two instructors as being the most effective but was chosen by four instructors as being the least effective. One of the instructors characterized word sort as both the least effective and the most effective strategy simultaneously for different reasons. This instructor held that it

was the most effective in terms of helping students understand the vocabulary, but that the instructional implementation was difficult which made it the least effective. Another instructor thought that the word sort helped students pull all the information together and organize their thinking.

Both the word-problem solving guide and the strategy involving scrambled solutions were chosen to be most effective by two instructors, however the two strategies were also chosen to be least effective by two single instructors. The word-problem solving guide was thought to be least effective by one instructor due to the students becoming mired by the writing involved. This same instructor reported that she also used her own solution method to instruct the students to solve word problems. Another instructor reported that it was the most effective strategy because it helped students to organize their work for solving word problems. The strategy for scrambled solutions was reported by one instructor to have helped “hammer home that every step is important.” This same instructor noted that she saw more solution steps on the final examination than in past semesters which she attributed to the use of this strategy. Another instructor reported that she thought the strategy for scrambled solutions reinforced the mathematics principles and their use for students. Lastly, this same strategy was considered to be least effective by one instructor because she reported having difficulty with it although she did not report having difficulty implementing it.

The vocabulary strategy was chosen to be most effective by one instructor, while the concept maps strategy was chosen to be least effective by one instructor. The vocabulary strategy was thought to be most effective because it “made

students aware of math words in math class.” The instructor who chose the concept maps to be the least effective strategy stated that this was due to the way she implemented and then did not review with the students. Interestingly, the strategies of word sort, scrambled solutions, and the guide for word problem solving were cited to be both the most effective and the least effective in terms of the instructors’ perception of supporting student learning of the mathematics content.

### **Instructors’ Implementation of Reading Strategies**

The quantitative analyses indicated no statistically significant difference between the control and treatment groups for course outcomes. One explanation for this could be the insufficient implementation of the strategies since the instructors did not complete a focused professional development addressing use or rationale for the strategies. These instructors were asked to be very explicit when explaining the purpose of a reading strategy and how it was connected to mathematics. However, as revealed in the classroom observations, seldom were the students given an explanation for the intent of a content area reading strategy, a rationale for why they were being asked to use a reading strategy, or an explanation of how a reading strategy connected to the mathematics. Every reading strategy had a handout for student use, and discussion questions were provided for the instructors to facilitate class discourse and to encourage the students to make connections and to form a deeper understanding. No reading strategy was designed to require a complete class period. Yet, seldom did the instructors consider the discussion questions as an important component of the

implementation of a strategy. Thus the instructors did not spend much time using the discussion questions.

Each instructor was provided a 3-ring binder with each strategy detailed. This binder included a brief introduction for the instructors, introducing the rationale for reading strategies as being “intended to focus students back to the textbook and to provide them with reading strategies they can use to pull information from the textbook,” as well as ways the students could use the strategies to organize ideas. This introduction also stated that a secondary purpose for using reading strategies was “to help students become independent learners and not depend solely on their instructor for information,...for students to be better able to use the textbook as a resource for learning.” Each strategy was designed to replace a portion of (or all) of a traditional lecture on a specific topic. The reading strategies place much of the responsibility of learning onto the shoulders of the students with the instructor acting as a guide and facilitating discussion with provided discussion questions to deepen student understanding. This introductory material for the instructor noted that, “You will not be dropping material in order to make time for the strategy activities – the activities *are* the lecture and practice. This is another way to teach students the material other than through straight lecture.” Nevertheless, it was not unusual for the instructors to use the reading strategies as a supplement to their lecture, limiting implementation and intent.

The instructor’s binder provided several components addressing intended mathematics instruction incorporating reading strategies. These included:

textbook section(s) covered, which class meeting to implement the strategy in, suggestion of when within a class period to implement, estimated time required, purpose of strategy, mathematics topic difficulty being addressed, materials provided, detailed instructions, a script with discussion questions, and any special notes. Every instructor received more handouts than needed for their students, keys to all handouts if appropriate, master blank copies of all handouts, and supplies such as highlighters and cards. The detailed instructions for implementation suggested appropriate modifications if time was a concern, in order to maintain implementation that would achieve the purpose of the strategy. Also the detailed instructions explained when group work was needed for a particular strategy. The script with discussion questions was intended to help the instructors introduce the strategy and implement the strategy. Discussion questions also had answers provided. Instructors were not required to prepare any of the materials for implementing a strategy. The intent was for as little additional time as possible to be required of the instructors outside of class preparing for implementation of a strategy.

Implementation of all eight content area reading strategies was observed at least once by the researcher; each treatment instructor was asked about use of every strategy during the second interview. Implementations were extremely varied, and occasionally an instructor did not implement a strategy. During the interview, most instructors responded that they implemented the strategy as directed by the guide, however observations documented this was often not the case. During observations, seldom were the students told why they were doing a

reading strategy and seldom were the discussion questions fully utilized as intended, if at all.

In the sections that follow, each of the eight reading strategies are briefly described and then drawing on the observations and interview data, the inferred implementation is described. The researcher did schedule classroom visits with the instructors in advance to ensure that a reading strategy was to be implemented. Occasionally, an instructor did not implement the planned reading strategy on the day of the observation. In this case, the researcher still observed the class.

**Get to know your textbook.** This reading strategy was designed for the first day of class to encourage the students to open the textbook and to become familiar with the textbook structure and organization. It did not directly address a mathematical topic. This strategy was designed for group work with a two-page handout. Each student in a group was given a handout to complete as a group to answer questions about the textbook (e.g., “Paging through Chapter 1, how does the author let you know when new ideas, rules, or concepts are being presented?”). Upon completion of group work the instructor was to ask provided discussion questions to assist the students with understanding how to use the information they wrote on their handouts.

Every instructor did implement this strategy, but they did not implement it fully. However, during the interviews, the instructors noted that they did appreciate that the strategy encouraged the students to become engaged with the textbook early in the semester.

This strategy was observed as employed in three classes. In each observation only a portion of the strategy was implemented, and students were told to answer only a select few questions. After partially implementing the strategy, one instructor informed the students that they would return to this later in the semester, however the instructor told the researcher during the interview that this strategy was never revisited. Little time was spent with the class in discussion about the textbook by any of the observed instructors. Another instructor distributed the strategy handout to the class as a take-home exercise to be turned in the next class period with no whole-class discussion in that particular classroom.

**Vocabulary.** This strategy served two purposes. First, research has shown that when students are familiar with the vocabulary they have better understanding of the material and can better read the textbook. Students are also made aware of possible confusions that they may have due to using an incorrect definition. Second, the upcoming unit reviews would use a word sort and the vocabulary words would be included in the word list.

While this strategy does not directly address a particular mathematical topic, it was designed to address those mathematics vocabulary words that have both an everyday definition and a definition in mathematics. Sometimes the definitions are the same and sometimes not. Students often enter mathematics classrooms and apply everyday definitions to mathematics vocabulary and not realize it, assuming that there is only one definition. This strategy covered new vocabulary drawn from the first three chapters of the textbook; it was designed



with a three-page handout for group work followed by discussion questions. The handout asked the students to write an everyday definition for a given vocabulary word, to write the mathematics definition as given in the textbook, and then to explain how the two definitions may be connected.

Every instructor indicated during the interviews that they implemented this reading strategy, but only two instructors said they taught it as written in the instructional guide. Overall, the instructors thought this reading strategy helped the students better understand the vocabulary, and they noted that the students seemed to enjoy the activity.

The researcher observed four classes that implemented this reading strategy. Two of the instructors explained the purpose for the strategy and how it connected to learning mathematics. Both of these instructors had several years of K-12 teaching experience. The two other instructors implemented only a portion of the strategy without providing an explanation of the purpose. One of these instructors addressed only part of the handout in class and gave the remainder of the items as a take-home assignment to be returned during the next class period. While this material included vocabulary from the first three chapters of the textbook, most instructors focused only on vocabulary words from the first chapter.

**Independent study guide.** This strategy served two purposes. First, it served to activate the students' prior knowledge on the material in the two textbook sections that are assigned as independent study (tests for divisibility, prime and composite numbers). These two sections were designated as

independent study by the course leader since these topics contained information students were familiar with and could be reviewed independently; therefore, class time could be saved. Second, it serves to guide the students through what could be the first independent study assignment that they have ever encountered in a mathematics course. This strategy may also reduce levels of mathematics anxiety by providing a guide for the independent study and by giving the students a reason to get started with the assignment. Students in developmental mathematics courses seldom have the ability or experience to organize their time for an independent study nor do they know how to approach an independent study. These students may have difficulty discerning what information is important in a section and what is not, as this is usually provided to them by the instructor. This reading strategy encourages the students to read the sections of the textbook before attempting the homework exercises, much as a lecture precedes homework. The three-page handout served to focus students on the reading by asking questions that the students were to answer. Additionally, the students are asked to write their answers in complete sentences, summarizing the information in the textbook, rather than simply recording a single fact. Since this was an independent study assignment without class time allocated to it in the syllabus, the instructors were free to decide how much time, if any, they would spend with discussion questions in class. The researcher did encourage spending some class time reviewing the guides.

During the interviews, only one instructor stated the strategy was implemented as written in the instructional materials. The other instructors gave

the students the handout, but did not discuss it once completed by the students. Several of the instructors also stated that they directly taught the content in these sections, contrary to the intention of the course syllabus. This negated the usefulness of using an independent study guide strategy.

Implementation of this strategy was observed in one class. The instructor gave the students the handout and told them to place it in their notebooks to be reviewed later. The instructor then proceeded to provide an instructional lecture addressing the independent study material.

**Word-problem solving guide.** The word-problem solving guide was designed to help students structure their thinking on how to approach and solve word problems; it was to be implemented twice during the semester. This strategy focuses students on reading the word problem and then organizing the information in a way that allows them to develop a solution. Students often have difficulty approaching and solving word problems in mathematics, as many times students have no idea how to approach the deciphering of a word problem. Unsuccessful word-problem solvers base their approach on the given numbers and keywords, whereas successful word-problem solvers are more likely to comprehend the problem by interpreting the context of the word problem, by choosing descriptive variable names, and by building a model.

Students were given several copies of the one-page handout. The researcher prepared several word problems with solutions and discussion questions for the instructors. The instructors were to demonstrate how to solve at least one word problem using the handout with the class and then students were to

work together in small groups to solve at least one more word problem. Upon completion of the group work, the instructors were to ask the prepared discussion questions. The instructors were also asked to assign one homework word problem to be completed using the handout to encourage students to apply a structure to their approach to solving word problems.

Two instructors admitted during the interviews that this strategy was not implemented at both points in the course. All the instructors felt the strategy did provide the students with a starting point for approaching word problems and that it could guide the students through the solution process. One instructor thought the second implementation went better since everyone was familiar with the guide including herself. Instructors reported that implementation was not a problem. This strategy required the students to write the answer in a complete sentence and to briefly explain why the answer was reasonable. While not typical in a developmental mathematics course, only one instructor felt that the intended writing by students distracted students from the mathematics of the problem.

Implementation of the word-problem solving guide was observed in two classes. One instructor read the script provided in the instructional guide to introduce the strategy and implement the strategy as suggested, although very few discussion questions were asked upon completion of word problem solutions. A second instructor did not follow the suggested directions. Instead of working one problem together as a class, the instructor gave each student three copies of the handout and instructed the students to work a problem from the textbook, but not one that was noted in the instructional guide. Thus there were no prepared

discussion questions. The instructor did not introduce the strategy nor explain how to use the word problem solving guide, nor did the instructor ever relate back to the guide when working additional problems on the board. Very few discussion questions were asked and none that were asked were provided by the researcher. Other than giving the students the guide, this strategy was essentially not implemented by this instructor.

**Word sort.** This strategy was to be implemented three times over the course of the semester, thus serving as a review for each of the three course examinations. This strategy was planned to consume more class time, as compared to the other strategies, since it provided an examination review. This strategy consisted of a closed word sort; the students were provided the words and the categories. It was designed to assist students in recognizing the relationships among the key concepts across different textbook sections and to develop a deeper understanding of the connections among the concepts, procedures, and vocabulary. It was to help the students synthesize the procedures and processes across the textbook sections so the students might better understand how the mathematics connected.

Instructors were to give the students two, one-page handouts during a class meeting prior to the review day, so the students could become familiar with the words and the categories. One handout listed all the vocabulary words for the material being tested; the second handout had the categories in a tabular format. On review day the students were to work in groups with the handouts. Each group was given a set of cards with each individual word and category on a card.

Words were listed on cards of one color, and categories were on cards of another. Students were also given blank cards of a third color in case they thought that a word belonged in more than one category. The groups were to use the handouts and cards to sort the words. The cards introduced a kinetic aspect to the strategy as the students moved cards from one category to another. The instructional guide informed the instructors that there was not one intended correct sorting of the words into categories, as the students could place the words into one or more categories as long as they could explain their thinking. The instructor was to follow up with discussion questions asking the groups to justify their placement of words into categories. The discussion questions were written to connect the words with the procedures, solution methods, and concepts addressed in the reviewed sections and chapters.

As revealed in the interviews, the instructors found that the time needed to complete the word sort review was demanding, and some instructors thought student participation was difficult to maintain. Four of the instructors did not implement the strategy three times over the semester as directed. Three instructors implemented the word sort strategy for all three examination reviews, three instructors used the word sort strategy for two of the three examination reviews, and one instructor used it only once. The instructors indicated that the many days of college closing due to winter weather during the semester had caused them to reduce class time originally planned for examination reviews. No instructor implemented this strategy as designed. Instructors were more comfortable providing their own course examination reviews demonstrating

practice problems and reviewing a list of topics to clarify what would be on the examination. When the word sort strategy was used, it was shortened, modified, and treated as an additional task disconnected from the mathematics and not serving the purpose of a review. It was shortened so the instructor could provide a “real” review, or it was quickly implemented in available time after the “real” review.

This strategy was observed on four occasions. Two additional scheduled observations of the use of word sort were not completed. In one case, the instructor forgot the materials, simply ending the class after 20 minutes. The other instructor did not conduct any review due to class time lost from college closings. One instructor did implement a shortened version of the word list and applied the discussion questions well. Another instructor implemented a modified version of the word sort; however this instructor did not allow students to use the textbook which was contrary to the intent. All strategies were designed to drive the students back to the textbook for needed information. This instructor also felt that each category was mutually exclusive and that a word could only be placed into one category. This led to students consistently asking her to tell them what category a word should be placed into. In one specific episode a student said he thought the word *remainder* should be placed into the category of *Type of Number*. The instructor disagreed and told him it belonged in different category. Very few discussion questions were used by this instructor. The researcher later asked the student why he made the choice he did. The student replied that when a

number does not divide into another number a whole number of times then there is a remainder and he thought the remainder is a type of number.

In another class, the observed instructor modified the use of the word sort by incorporating a concept web and a jigsaw. This instructor gave the students the handouts with words and categories, then she took one of the categories and drew a concept web onto the board with one category in the center and four words connected at each corner. This was the instructor's view of which words should be connected with a category. The instructor then gave the students a new handout with the format from the board. For the jigsaw portion, the students were put into groups. Each group was given a different category and was told to use the word-list handout to select the words that matched their category. The students were to give the instructor the completed concept web for their group, which the instructor then placed on the course website so that the students could view the work of the other groups with the other categories. Few of the provided discussion questions were used. This instructor did not implement this strategy as intended.

The remaining observation revealed an instructor providing the students with the handouts for a different course examination review. The researcher had a single copy of the correct handouts which the instructor then used to write the categories onto the board and called out one word at a time and asked students which category or categories the word should be placed. Some discussion questions were used, however, only about 15 minutes was allocated for this reading strategy, and all words were not used.



The students observed seemed to enjoy using of the cards and working in groups to place words into categories. The researcher observed members of groups trying to convince the others why a word should be placed into a category. When members could not come to agreement, the word would be placed into two or more categories.

**Self-evaluation.** The self-evaluation strategy was intended to encourage students to question their understanding of a passage from the textbook as they read and to take responsibility for their understanding. This strategy addressed two issues. First, the mathematics of the passage chosen (interpreting fractions with variables) is typically problematic for developmental mathematics students every semester. Second, the strategy emphasized the uniqueness of mathematics textbooks and encouraged students to be aware that slowing down their reading speed, rereading portions, and asking themselves if they understand what they just read are reading strategies they can use to better understand the textbook. They generally often do not realize that because mathematics textbooks are very dense and frequently do not repeat information with the same representation, these are good strategies. Students often try to read mathematics textbooks using the same strategies they use for novels and newspapers. Many students think that using these reading strategies are signs that they are not good readers and not capable mathematics students.

The students were given a one-page handout which contained a passage on the topic of fractions with variables from the textbook and were given one yellow highlighter and one pink highlighter. They were asked to highlight everything on

the page in pink (including headings and captions) if they were confident enough in their understanding to explain that content to another student. Otherwise, they were to use the yellow highlighter. The purpose for the highlighters was to promote the students' awareness of what they were reading: Did they understand it well enough to highlight in pink? Upon completion of this task, the instructors were to ask discussion questions which focused on how the students read differently because of the highlighters, on how they decided to highlight in pink or yellow, and on the mathematics of the passage.

During the interviews two instructors indicated they did not implement the strategy. The college closings caused one instructor to ask to implement the strategy later in the semester and the researcher prepared an equivalent handout from a section later in the textbook. Another instructor reported only covering the first paragraph of the handout.

The implementation of the self-evaluation strategy was observed twice. One instructor clearly introduced the purpose for the strategy, although the directions were not explained to the students. The students were not told that everything on the page needed to be highlighted allowing for text to be "neither yellow nor pink." This instructor did use several of the discussion questions, focusing on how the students read differently and their metacognition activity rather than on the mathematic topic being read. The other instructor did not explain the purpose of the strategy but did read the directions directly from the script provided in the instructional guide. This instructor asked most of the discussion questions about the mathematic topic, but ignored the discussion

questions about the activity of reading mathematics and metacognition, the main point of the strategy.

**Scrambled solutions.** The strategy of scrambled solutions was to be implemented twice during the semester. This strategy blended equation solution steps, mathematical literacy, reading the textbook, and writing. The students were to sequence the scrambled steps of a solution for an equation. With each solution step, the students were to write an explanation and state the property/identity/principle used (if one was used). This strategy also addressed the literacy of reading equation solutions. Mathematical literacy includes the organization of the solution, keeping the equation balanced, and understanding the notation and properties/identities/principles. This strategy may help students better understand the sequencing of a solution and how to “read” the solution sequence.

The strategy for scrambled solutions was designed to address the difficulty which students have when solving equations. They often work in circles, applying a procedure and then applying another procedure that “undoes” what the first procedure accomplished. This can happen when the approach to solving equations has a goal but not a plan. Additionally, students often do not connect the names of properties/identities/principles with the action entailed in a solution, such as the Additive Inverse, Additive Principle, or the Commutative Property.

The researcher prepared scrambled solutions for four equations, each on a one-page handout. The instructors were asked to work one scrambled solution with the class to model how the handout was to be completed. Next the students

were to work in groups to complete one or more of the remaining scrambled solutions with everyone working on the same equation. A set of cards, each with a solution step, was give to each group for the equation being solved. The cards were to be moved into differing sequences until the group agreed upon a sequence for the solution steps. This added a kinetic aspect to the strategy. Upon completion the instructor was to ask the prepared discussion questions to help the students make connections between what they were doing and the mathematics content.

During the interview, only one instructor reported implementing the strategy as written, and one other instructor admitted to only implementing the strategy once. The remaining instructors reported modifying the strategy such as identifying the original equation, not instructing the students to write an explanation or name which property/identity/principle was used, and not using the cards. Note, not using the cards removed the kinetic aspect of this strategy.

This strategy was observed in two classes. Neither observed instructor implemented the strategy as intended. One instructor did not demonstrate use of the strategy with a problem with the whole class, explain the purpose of the strategy, or show the students how to complete the handout. This instructor told the students to work individually, not in groups or pairs, and each student received one of the four handouts; no cards were distributed. Students were told to use the third column on the handout to explain what procedure was done for a step (e.g., subtraction, addition), not the property/identity/principle applied and no discussion questions were asked. The other instructor did complete a handout

with the class and then had the students work another equation in groups (everyone had the same equation). But again, the students were not instructed to name the property/identity/principle applied to each solution step. This instructor did use some of the discussion questions asking the students to explain what operations were done to move from one step to another, without ever mentioning any of the explanatory properties/identities/principles. The students observed enjoyed using the cards to help them sequence the solution steps.

**Concept maps.** This strategy was to be completed at three different times over the course of the semester due to the topic occurring over two separate chapters. The first two concept maps (Concept Map 1, Concept Map 2) were to scaffold to the third concept map (Concept Map 3). The purpose of the concept maps was to present the conversions among fractions, decimals, and percentages as graphical representations, a schematic differing from the textbook's presentations. Concept maps present abstract ideas more concretely as well as organizing interrelated ideas. In Concept Map 1 (converting from decimals to fractions), students were only asked to provide examples from the textbook to be written onto the handout. In Concept Map 2 (converting from fractions to decimals) students were asked to provide examples and also to review the textbook by writing the definitions for the new vocabulary introduced (e.g., terminating decimal, repeating decimal) onto the handout. Concept Map 3 was in the format of a labeled 3x3 array. Each cell provided room for students to write the steps needed for each of the six conversions (fraction to decimal, decimal to

fraction, fraction to percentage, percentage to fraction, decimal to percentage, percentage to decimal) and to provide an example.

This strategy addresses the difficulty students can have converting among decimals, fractions, and percentages. Students often see these conversions as six separate sets of procedures that they need to memorize. The concept map strategies may allow the students to see that there are several procedures that are repeated within each of the conversions. Additionally, it may reinforce for students that the three representations (decimal, fraction, and percent) are equivalent.

Each concept map was a one-page handout. Concept Map 1 was intended to be given to students as homework; very little time would be needed to complete this concept map. Concept Map 2 was intended to be completed in small groups during class with some discussion questions asked that would also cover Concept Map 1. Students could use the first two concept maps to partially complete Concept Map 3, along with use of the textbook in groups in class. Once completed, instructors were to ask prepared discussion questions. More discussion questions were to be asked with Concept Map 3 as it was essentially a summary of the topic incorporating the first two concept maps with vocabulary.

When interviewed, every instructor indicated that all three concept maps were implemented, although not always as intended. Five of the instructors favored Concept Map 3 and thought it helped the students “see” how the different conversions were related. The remaining two instructors stated they were not sure if it helped the students, while one of these instructors admitted to not giving the

students much time to work. There were no difficulties with the implementations except for the class time needed as noted by one instructor.

This strategy was observed in five classes. The first instructor gave the students all three concept maps at once. This instructor worked examples for the Concept Maps 1 and 2 on the board and then instructed the students to complete their handouts from the information on the board. The students never needed to refer to the textbook to complete the first two concept maps. For Concept Map 3 the instructor provided the students with a fraction, a decimal, and a percentage to use for this handout. The students were allowed 5 minutes to work on the handout individually before the instructor demonstrated the task on the board, telling the students to copy any uncompleted work onto the handout. The students were not required to use the textbook or to make connections on their own.

The second instructor was observed implementing Concept Map 3. This same instructor stated in the interview that Concept Map 2 was given as homework and never reviewed in class. This instructor did not use group work when implementing Concept Map 3; it was implemented as a demonstration for the class with the instructor completing Concept Map 3 on the board while asking short-answer questions to prompt the students to “help” complete the handout. This instructor did connect the Concept Map 3 information to the first two concept maps and the textbook.

When observing a third instructor’s implementation of Concept Map 2, the handout was never used or referenced. This instructor drew a concept map onto the board with examples detailing the steps needed to convert from a fraction to a

decimal, without ever mentioning the handout for Concept Map 2. The students were never required to consult the textbook or make connections on their own, all the work was demonstrated for them. For another observation, the fourth instructor distributed the handout for Concept Map 1 and then explained its usage to the students. Nothing more was done.

The final observation was an instructor implementing Concept Map 3. Two copies of the handout were given to each student. The instructor completed the work needed for one handout on the board. The students were confused between the area to list the steps for conversion and the area for an example; the instructor did not explain and only worked examples. The students were to complete the second handout individually and were given a fraction, a decimal, and a percentage to use. The students who the researcher observed completing this task were only completing the area for an example and not listing the steps required. To summarize the work done, the instructor read from the key for Concept Map 3 provided in the instructional guide. The key only contained the procedure for each conversion, no examples.

Overall, the instructors had a suggested improvement for this strategy that they used. Originally, the students were to find their own examples to complete Concept Map 3. The instructors gave the students the same decimal, the same fraction, and the same percentage so everyone was working on the same values when completing the steps needed for a conversion. The instructors felt this made it easier to ask questions and to check student work.



## **Fidelity of Implementation**

The text that follows profiles each treatment instructor individually to explore their overall implementation of the reading strategies throughout the semester. Pseudonyms are employed to preserve confidentiality in addition to all instructors being referred to as female.

Arlene was an adjunct instructor who had much experience teaching developmental mathematics. Her classroom was extremely structured in all ways. She did implement several of the reading strategies, but did not explain or frame the reading strategies for the students. Students in her classes were not given much time to accomplish the reading strategies, and discussion questions were rarely utilized. She treated the reading strategies as separate tasks from the lecture. Her lectures were mainly focused on mathematical procedures.

Bonnie was an adjunct instructor who possessed a technical degree with advanced mathematics courses. She generally followed the directions in the instructional guide, although she was uncomfortable with implementing many of the reading strategies due to her lack of experience and background in education. She relied heavily on the script provided in the instructional guide when implementing the reading strategies. It was evident in the classroom observations that she attempted to implement the reading strategies as intended, however, the result was that the reading strategies were sometimes separate tasks from the lecture. Although she tried to connect the mathematics procedures the students were learning with the concepts, her lectures were mainly procedural. She would

have benefited from professional development for administering the reading strategies.

Cindy was an adjunct instructor also with a technical degree which required advanced mathematics courses. She generally followed the directions in the instructional guide, although she did not always allow students to use the textbook when engaging in a reading strategy activity. Her reasoning was that the reading strategies were opportunities for the students to realize what they do not yet understand. It was evident in the observations that she attempted to implement the reading strategies as intended; however, the result was that the reading strategies were sometimes separate tasks from the lecture. Although she tried to connect the mathematics procedures the students were learning with the concepts, her lectures were mainly procedural. She would have benefited from professional development for administering the reading strategies.

Debbie was an adjunct instructor whose collegiate background did not require mathematical expertise. She would have greatly benefited from professional development addressing the reading strategies. It was evident that she was uncomfortable with implementing many of the reading strategies and reported to the researcher that she did not see the point of many of the reading strategies. She did not explain or frame the reading strategies for the students. Additionally, she did not follow the strategies with discussion questions. She was more comfortable with a traditional-style, lecture format wherein she illustrated several examples and emphasized the procedures. Therefore, the portions of the reading strategies which focused on reading or comprehension were disregarded.

In her classes, reading strategies, as a whole, were treated as separate tasks from the lecture.

Emily was a full-time instructor who possessed a teaching license. She was very experienced with the developmental mathematics courses and students. She explained and framed the reading strategies well for the students. She did ask a few discussion questions; however, her implementation of the reading strategies and the discussions were often rushed. She modified several of the reading strategies, typically maintaining the integrity and the purpose for each. She also was very mindful of her students and their need to understand both procedures and concepts.

Florence was a full-time faculty member, possessed a teacher certification, and also had experience teaching teacher education courses. She was very good with explaining and framing the reading strategies for her students. In addition, she did use the discussion questions to encourage class-wide discourse. She occasionally made small modifications that she thought best served her students while still maintaining the integrity and purpose of a reading strategy. She was very mindful of her students and their need to understand both procedures and concepts. She was able to weave the reading strategies into her normal instructional practices.

Gabrielle was an adjunct instructor who also held a teaching license. She was initially very enthusiastic about working with the reading strategies. However, she was greatly affected by the college closing for winter weather due to the time and days of her class meetings. She reported to the researcher that she

never felt like she could get on schedule again after the closings. Therefore, she did not implement several of the reading strategies, and when a reading strategy was implemented, it was only partially implemented. Her classroom presentations did endeavor to connect the mathematics procedures the students were learning to the concepts.

Several of these instructors seemed to prefer using a “universal script” (Battista, 2001, p. 43) for their instructional practice. This script includes the familiar teaching practices of a warm-up, review of homework, teacher explanation with examples, individual or group practice, and assigning of homework for the next class meeting. This script is associated with the view of mathematics is as “mastery of a fixed set of facts and procedures” (Lloyd, 2002, p. 149). The script seems to encourage the instructor to clarify meaning to aid student memorization and procedural fluency. Incorporating content area reading strategies deviates from the “universal script.” As a result, often the reading strategies became “add-ons” disconnected from the mathematics. This same “universal script” was observed in the control sections.

## Chapter 6 – Discussion

This study investigated the impact of incorporating content area reading strategies into a prealgebra developmental mathematics course at a community college. This study reviewed theories and research in the fields of reading and literacy, as well as mathematics education, to characterize approaches and content area reading strategies which could be incorporated into college-level, prealgebra, developmental mathematics courses with the goal of increasing students' mathematical proficiency through their enhanced comprehension of mathematics content from reading the course textbook. The use and design of the reading strategies by the researcher was grounded in three theories: Rosenblatt's Transactional Reading Theory, Kintsch's Construction-Integration Model of text comprehension, and the Mathematical Principles of Learning from the National Research Council publication *How Students Learn: Mathematics in the Classroom* (Donovan & Bransford, 2005).

This study employed a quantitative control-treatment design to investigate whether the incorporation of content area reading strategies into the instructional practices of a community college prealgebra developmental mathematics course would be related to students' overall mathematics achievement in the course as measured by standardized course assessments administered across all sections and the course passing rate. Data collection consisted of the standardized course assessments, student demographic data provided by the college, student background information garnered from a researcher-designed questionnaire administered to the students, and additional instructor information detailing

education background and educational teaching experiences as collected from a researcher-designed questionnaire completed by the instructors. Faculty were also interviewed. All faculty, treatment and control, were interviewed to ascertain their perceptions of developmental mathematics courses and students. The treatment instructors were interviewed a second time to learn about their perceptions and implementations of the reading strategies. Observations of both control and treatment classrooms were also conducted.

This study offered many challenges. These students were lower performers in mathematics and therefore were in a prealgebra developmental mathematics course due to performance on mathematics placement tests. Thus the distribution of these students' prior mathematical achievement was not normally distributed, rather it was skewed. While this study was intentionally conducted with such a select population this did raise a challenge for identifying significant change. Furthermore, many of these students were also lower performers in reading. A large percentage of the students had been previously taught but had not retained or understood the content presented in the prealgebra developmental mathematics course. This may imply either the presence of established mathematical misconceptions or limited motivation to again address the same content. Additional challenges included the large percentage of adjunct instructors with a variety of educational backgrounds and teaching experiences. This also introduced the challenge of adequate time to interact with the adjunct instructors outside of the classroom for the researcher.

This final chapter provides a discussion of the results of this study. The discussion is presented in four sections. The first section is a summary of the results and overall conclusion of the study, while the second section presents the contributions and implications of the study. The third section explains the limitations of the study, and the last section makes suggestions for future research.

### **Summary of Results and Overall Conclusion**

The research was designed to explore the impact of incorporating content area reading strategies in a prealgebra developmental mathematics course in a community college. The reading strategies were designed to aid students with specific topics which were known to be particularly difficult in the course. Furthermore, each reading strategy was designed with the intent that the community college students would interact with their course textbook to complete the strategy, taking on more of the responsibility for learning. The implementation of each reading strategy did not require a full class meeting and the time spent on implementation was intended to replace normally delivered lecture on the material, therefore not adding material for instructors to cover. The intent was to change the instructional domain for delivery of the course content by incorporation of the reading strategies, not the time required. These reading strategies were to be tools for facilitating the students' learning and comprehension of mathematics. Prior research had shown that students have not learned how to "read to learn" from their mathematics textbooks. The textbooks are mainly used by community college students as a resource for completed examples and homework problem sets. This compels the students in

developmental mathematics courses to rely extensively on their instructor to learn the mathematics. The consequence of this is that community college students do not become independent learners of mathematics. Knowledge of how to read to learn from expository text is a skill that is needed by workers and citizens in the increasingly literate world of today.

### **Summary of Quantitative Results**

The results of the quantitative analysis of the data indicate that the incorporation of content area reading strategies did not improve student performance in the prealgebra developmental mathematics course. This result was determined through the use of two performance measures: the average number of points scored on the common course assessments which consists of the quizzes, course examinations, and the final examination (Utilized Course Points) and final course completion status, which is whether students passed or failed the course. There was no statistically significant difference between the treatment and control groups for either measurement.

The students who participated in this study ranged from 18 to 61 years old, with approximately one-half of the students being 18 to 19 years old. The results indicated that a student's age did not impact their performance in the course. Older students who were returning to schooling via the community college had a comparable likelihood of passing the course as compared to younger students who had recently graduated from high school. Approximately two-thirds of the students participating in this study were female. In this study, being female positively impacted a student's chance of passing the course. In fact, females



were nearly 3 times more likely to pass the course than their male classmates. It is interesting to note that students of a minority race/ethnicity earned fewer Utilized Course Points (a possible of 489 out of 780 points) but this had little impact on whether a student passed the course or not. This implies that minority students were able to compensate for the deficit from the standardized measures defined by the Utilized Course Points through other assessments which were part of the course (See Table 2). The other assessments represented the remaining 291 of the 780 possible points which could be earned in the course.

Students' prior knowledge in reading and mathematics did impact their performance in this course. Higher scores on the prealgebra and reading placement tests resulted in an increased probability of passing the course and doing well on the common course assessments. Prior knowledge in reading impacted achievement in this course in a similar manner as prior mathematical knowledge. This implies that reading is an important factor in learning mathematics even though, in this study, the use of content area reading strategies did not result in a statistically significant improvement in students' mathematics achievement within this course.

Neither level of implementation, low nor high, was found to improve students' mathematical achievement in the course. Though, further exploration of the levels of implementation of the reading strategies and the impact on student achievement showed a pattern. For the Utilized Course Points measurement low levels of reading strategies implementation was associated with statistically lower student performance in the course, as compared to High Implementation or

control status. At the same time, High Implementation had the same impact on student achievement as did no implementation of reading strategies. The reason for this is unknown; however, the manner of the implementations may have caused students to be distracted from the mathematics or may have caused confusion.

### **Summary of Qualitative Results**

The interviews and observations provided interesting information. Across the first interview, which was conducted with all instructors, there were two recurring themes. The first concerned how positively the instructors viewed the older students. The instructors felt that the older students' maturity and motivation could or would overcome any lack of confidence and prior mathematical knowledge they may possess. The instructors' perception was that course work could be balanced out by life experience, maturity, and motivation. In fact, there was no difference in course performance associated with age. The second theme was the lack of study skills exhibited by the students. Study skills involved anything from bringing materials to class (e.g., pencil, textbook, calculator) to asking for help. Reading strategies have been partially defined as providing students with methods for organizing information for recall (Conley, 2009). The same can be said about study skills. In theory, the inclusion of reading strategies in mathematics classrooms could address some aspects of study skills.

From the second interview, which was conducted only with treatment instructors, the instructors reported a favorable impression of the content area

reading strategies. The instructors also felt that the students enjoyed working with the reading strategies. Additionally, instructors thought the group work, which was part of many of the reading strategies, helped present some content in a less intimidating manner to the students. The instructors reported that the reading strategies did help some of the students better understand particular topics; two instructors even reported that the use of the reading strategies increased their own understanding of the mathematics.

During this same interview, most instructors noted that they implemented the reading strategies as directed by the guide; however this differed from the classroom observations conducted. Quality of implementation was not measured, but level of implementation was observed. The observations revealed that while the instructors were not comfortable incorporating the reading strategies into their normal instructional practices, they did make an effort. Nonetheless, several of these instructors still seemed to prefer using a “universal script” (Battista, 2001, p. 43) for their instructional practice. The incorporation of content area reading strategies deviated from that “universal script.” As a result, often the reading strategies became “add-ons” disconnected from the mathematics. Frequently, the reading strategy was rushed through so the instructor could still present a “proper” lecture on the material.

## **Conclusion**

Taken together, the quantitative and qualitative results provide information about incorporating content area reading strategies within a prealgebra developmental mathematics course at a community college. The

quantitative analyses indicated that there was no statistically significant difference between the control and treatment groups as measured by course outcomes. In this study, the level of implementation, the degree to which there was fidelity of implementation, was extremely varied and overall not very high. Research has found that high fidelity of treatment is related to increased student achievement on reading comprehension and vocabulary (Hairrell, Rupley, Edmonds, Larsen, Simmons, Willson, Byrns, & Vaughn, 2011). The reading strategies designed for this study were intended to support students' reading and comprehension of their textbooks in order to improve their course mathematics achievement. The results show that this did not occur, possibly due to low implementation of the treatment. In fact, the quantitative analysis indicated that low implementation of reading strategies was more detrimental to the students than not using reading strategies at all. An explanation for this may be that insufficient implementation of the reading strategies either confused or distracted the students, negatively impacting their mathematical focus or understanding.

Students who had high prior reading placement test scores seemed to have higher mathematics achievement in the prealgebra developmental mathematics course. This implies reading skills do impact mathematics achievement. But this study did not show a benefit for incorporation of the reading strategies. This may signify that the reading strategies did not target areas of possible growth in reading skills for the students. However, it should be recognized that it is very difficult to increase reading skills and literacy significantly in a limited instructional setting such as utilized in this study. Further this study examined the

impact of the application of reading strategies as measured by mathematical assessments rather than direct evaluation of students' reading skills.

These findings should be taken with caution since approximately 75% of these students had prior "exposure" to mathematical content above the content level offered in the prealgebra developmental mathematics course (see Table 6). The results of this study may differ with other populations such as middle school students who would be seeing this mathematical content for the first time. This study also relied on transfer using mathematics measures to evaluate use of the reading strategies. The achievement measures of the quizzes, course examinations, and final examination were not designed to assess application of the reading strategies in a mathematical context. Transfer of learning in this situation is a high bar.

Overall, the data collected indicate that community college mathematics instructors cannot easily incorporate reading strategies into their normal instructional practices. Data from classroom observations and instructor interviews indicated that even if instructors believed that reading strategies held value for the learning and teaching of mathematics, their instructional practices still treated the reading strategies as separate from the mathematics. These instructors were well-meaning and desired to do a good job teaching the content to their students however, most were still more comfortable with their normal instructional practices and had a difficult time truly weaving the reading strategies into their teaching style. It is unlikely that this pattern will change without professional development or other instructional supports.

If reading strategies are to be incorporated into the instructional practices of instructors teaching developmental mathematics courses, there is a critical need for professional development. Professional development may provide instructors with necessary experience and knowledge for integrating reading strategies into their instructional practices. It could also provide the instructors with an understanding of how reading strategies can be a valuable tool for supporting and enhancing the teaching and learning of the mathematics, and not simply serve as disconnected “add-ons” to a mathematics lecture. This could address the instructors’ perceptions or beliefs about incorporating reading strategies into their instructional practices.

### **Contributions and Implications**

#### **Contributions**

The results of this study advance the growing body of knowledge about the use of reading strategies in mathematics courses at the college level. The main finding of this study is the critical need for community college instructors of prealgebra developmental mathematics to have professional development when asked to provide instruction in a manner different from their normal style. Specifically, this study provides evidence that instructors need professional development if reading strategies are truly to be integrated into mathematics courses as a tool to help students better learn the mathematics and to become independent learners.

A major contribution from this study is to call into question the policy of not requiring college-level faculty to earn continuing professional development

credit, as it is a frequent expectation for K-12 teachers. In particular, adjunct faculty of developmental mathematics courses are seldom required to take part in any professional development. The assumption is that teachers need professional education to continue learning, to become better teachers, and to better serve students.

A further contribution is that the instructional lens and instructional materials developed for the design of the treatment incorporating reading strategies in this study are unique in their application to and focus on prealgebra topics for a community college population. Additionally, the reading strategies, though being used to support mathematics instruction, were grounded mainly in theories for reading. This study extended the applicability of Rosenblatt's Transactional Reading Theory into the field of mathematics. Although Kintsch's CI Model has been extended to mathematics, its primary extension had been to mathematics of elementary-school-level word problems. For this study, Kintsch's CI model was used to facilitate deeper levels of comprehension, of the prealgebra and algebra topics which the reading strategies addressed.

This study also contributes to the body of knowledge in a unique manner in that the researcher is a mathematics educator with a mathematics background who looked at the mathematics course studied through the lens of reading strategies. Often times, interdisciplinary studies of mathematics and reading are done by researchers from the fields of reading and literacy who do not possess a deep understanding and teaching experience of mathematics. Possessing a mathematical background and teaching experience in college-level mathematics

allowed the researcher to design and modify reading strategies to target specific aspects of mathematics that otherwise may not have been considered.

### **Implications**

Although no statistically significant difference between the mathematical achievement of students in the treatment group and the control group was found, this study does not imply that there is no value in incorporating content area reading strategies into the mathematics. When the results of the quantitative and qualitative are taken together the limited level of implementation of the treatment was exposed. The implication is that the community college mathematics instructors should have professional development if the intent is for them to truly incorporate reading strategies into their instructional practices for mathematics. Additionally, if the intent is to help students become independent learners with the knowledge to read their mathematics textbook and learn from it, then only full and complete implementation of the reading strategies should be accepted. Indeed, this study found that no implementation of reading strategies was preferable to inadequate implementation, as determined by student achievement. Low implementation of the reading strategies was associated with lower students' mathematics achievement as compared to than no implementation of reading strategies. The professional development addressing reading strategies should include continued support for the instructors during implementation to ensure instructional practices have changed. From this study, it is known that the students were willing to become involved in completing the reading strategies and



seemed to enjoy the activity. The difficulty arose with the implementation of the reading strategies by the instructors.

Many community colleges have two main forms of professional development, personal responsibility of the faculty member and the institutional responsibility (Fugate & Amey, 2000). However, there are no requirements for continuing professional development for adjunct instructors. This is important since, in this study, the developmental mathematics courses were taught predominantly by adjunct faculty. Many community colleges struggle to ensure that all courses offered are “covered” by faculty and therefore heavily recruit adjunct faculty to cover courses particularly courses added to the semester schedule at the last minute. The design of professional development should take into account adjunct faculty schedules and needs. Many adjunct faculty teach at the community college in addition to their primary jobs and family responsibilities. It has been suggested that professional development be used to inform adjunct faculty about teaching pedagogy, especially new techniques (Greive & Worden, 2000) such as incorporating content area reading strategies into their mathematics lessons.

More specifically, to encourage mathematics faculty to incorporate reading strategies into their instructional practices professional development would need to address the instructors’ conceptual understanding of the individual reading strategies and their motivation. The instructors would need to understand not only the intent and potential of the reading strategies but also why the strategies would be beneficial to student learning in mathematics.

Professional development should directly address instructors' perspective on their typical use of the mathematics textbook in the course and their interpretation of their students' use of the textbook. Instructors often do not use the textbook as the valuable resource it is and this perspective should not be ignored, but could be modified. In a prealgebra developmental mathematics course, ideally, students would understand how their textbook is organized and how to use it as a resource for additional explanations of mathematical concepts apart from their instructor's explanation as well as for examples and exercises. This would encourage these prealgebra developmental mathematics adult learners to become independent learners by providing them with the experiences, reading strategies, and skills necessary to do so.

Professional development could provide the instructors with their own experience of learning how to model the use of the mathematics textbook for their students. Instructors are aware of weaknesses their students either bring to the prealgebra developmental mathematics course or will exhibit during the semester. Some weaknesses may be a direct reaction to an "inconsiderate" mathematics textbook which may provide a poor explanation of a topic. Professional development could help the instructors design reading strategies specifically to attend to student weaknesses and practice implementing the reading strategy prior to usage in their classrooms. Instructors are more likely to try something new in their classrooms if they have a measure of comfort with it. Professional development offers an avenue for prealgebra developmental mathematics

instructors to receive guidance and practice with incorporating reading strategies into their instructional practices.

### **Limitations**

This study contributes to the fields of mathematics education and reading, specifically for the topic of content area reading strategies. There are limitations to the conclusions that can be drawn from these findings. As is the case for all studies in the field of education, the conclusions of this study are limited by the overall design. The instructors and students in this study were associated with a prealgebra developmental mathematics course at a mid-Atlantic region community college with multiple campuses; caution should be exercised in generalizing the results of this study to other populations. Additionally, this study was conducted during the spring semester and therefore repeating students were enrolled in greater numbers than are typical in a fall semester. Both the students and the instructors were volunteers for this study, and therefore the bias of self-selection was introduced into the study. Another limitation is that 10 of the 13 course instructors were adjunct instructors with a wide variety of educational backgrounds and differing levels of teaching experience, these instructors also resisted additional time requirements for course preparation. Thus, the instructors were not provided with organized professional development. This meant that the quality of implementation of the content area reading strategies varied considerably.

## **Future Research**

Given the results and limitations of this study, there are many possible follow-up studies which can be completed to build upon this work in order to advance the field. First and foremost, if a study similar to this one were to be conducted, professional development designed to teach instructors how to incorporate reading strategies into their instructional practices and to address relevant presumed benefits of reading strategy use would need to be a requirement of all participating instructors. Further studies should explore the best forms of professional development particularly for the large numbers of adjunct instructors in community colleges who help staff the instructional ranks of developmental mathematics. Any further studies specifically focused on professional development could learn from the variation in the levels of implementation of the reading strategies in this study which reflect the challenge of addressing instructors' conceptual understanding of the intent and potential offered by use of the reading strategies or may reflect the challenge of integrating the reading strategies with mathematical objectives and goals. Additionally, longitudinal studies could be conducted to assess how instructors make changes in their instructional practices as they begin weaving reading strategies into their lessons. As learned from two instructors in this study, their own understanding of mathematics increased due to their participation. This adhoc finding could be explored further.

Further studies may also limit the focus of the treatment. The number of different reading strategies implemented throughout the semester could

be limited as this study had eight different reading strategies in 14 implementations which may have been too many. Limiting the number of reading strategies to one or two but with several implementations may provide better results as instructors become more familiar and comfortable with a reading strategy that has more than one implementation. The instructors in this study reported being more comfortable implementing reading strategies which were repeated. Moreover, further studies may also limit the reading strategy focus to a singular mathematics topic unlike this study which included several topics. This study may have included too many reading strategies on too many different mathematical topics for the instructors to learn and implement with high fidelity. Furthermore, studies could select reading strategies with specific mathematics objectives in mind such as increasing students' ability to approach and solve word problems.

Apart from the need to study professional development for instructors, studies focused on specific reading strategies and their impact on students' mathematics achievement should be done. Further studies should explore ways to assess if a reading strategy has helped to increase student knowledge of a topic and if so, how. The assessments could be formative and/or summative. In this study, the intended implementations of various reading strategies included discussion questions. Future studies could evaluate to what degree the reading strategy activity increased student mathematics knowledge compared to the degree that discussion questions increased students' mathematical knowledge. Similarly, a longitudinal study could be conducted to follow students who have

participated in a mathematics course which successfully implemented reading strategies to subsequent mathematics courses to observe which, if any, reading strategies they still employ and why.

Finally, while this study focused on a prealgebra developmental mathematics course at a community college, similar studies could be done for other levels of mathematics and at other post-secondary institutions. Student populations differ from course to course and from college to college. While there will be similarities across courses and colleges, the differences may be the key to developing focused content area reading strategies which foster increased student mathematical knowledge.

*Appendix A*

Course Syllabus

## XXXXX Prealgebra and Basic Geometry

### Course Description and Objectives

Students enrolled in XXXXX review arithmetic properties and the order of operations through the study of signed numbers, variable expressions, and the solution and graphing of linear equations. Basic geometry is introduced through the use of area and perimeter. Assignments throughout the course focus on the development of communication skills, problem solving skills, and effective study habits, especially as they relate to the study of mathematics.

XXXXX classes meet on campus for instruction and assessment as scheduled each week. Between classes students complete assignments from both the **textbook** and the **Hawkes Learning Systems (HLS) software**.

It is imperative that the student meet all the objectives of this course in order to move on to the next level of mathematics.

Students completing the course successfully should be able to:

- Use effective study habits to develop a better understanding of mathematical concepts and improve their use of mathematical skills.
- Apply mathematical skills to address a variety of problems with multiple operations and signed numbers, including fractions and decimals.
- Demonstrate how mathematical operations model relationships between quantities by converting English phrases to algebraic expressions, and word problems to equations that represent the problems.
- Communicate about mathematics orally and in writing using appropriate vocabulary.
- Demonstrate increased self-confidence and perseverance with mathematics.

Students taking developmental math courses are sometimes frustrated that they are not having the same success in math as in other courses. They often become more successful when they understand that not all subjects should be studied in the same way, and begin to apply effective study habits for math. The assignments in this course have been designed to help students incorporate effective strategies for studying math into their weekly schedules. Completing all assignments will increase the likelihood of meeting the course objectives. Class participation is an important part of your learning. It is imperative that you ask questions about problems that gave you difficulty. When possible, ask questions before class by arranging to meet with your instructor, a tutor, or other students.

#### **Auditing and Withdrawing**

Students who are **AUDITING** this course are expected to complete all assignments and assessments, and to be regular in class attendance. Any student registered to audit the course must speak to the instructor about these requirements and complete an Audit Contract before the second class session.

If you choose to withdraw from the course or change to audit status, you must do so by submitting the necessary paperwork to the Registrar by the deadline noted with "Important Dates." It is your responsibility to begin the withdrawal/audit process early enough to have it completed by this date.

If you do not complete the withdrawal process with the Registrar, you are still considered enrolled in the course even if you stop coming to class.

If you wish to **change your status to "audit"** you must meet with your instructor and complete an Audit Contract before submitting it to the Registrar. The contract will state your



requirements to receive the grade "AU." An audit form will be accepted only if it has been signed by the instructor and Chair of the MTH division. Again, it is your responsibility to begin this process early enough to allow time to have it completed by the deadline date.

### **Assignments and Assessments**

Most class work and assignments will come from the required textbook and software. Your instructor may supplement these sources by providing you with additional materials. All quiz and exam questions will be based on material in the textbook and software. All work needs to be completed in a neat and organized manner. To receive full credit for work on both assignments and assessments, all relevant work and steps **must** be shown. Assignments, as well as assessments, are indicated on the Course Schedule.

Assignments will not be accepted late. Assessments for this course include seven quizzes and four exams. You must be present in class to take a quiz; there are **NO** opportunities to make up quizzes before or after class. One zero grade will be dropped as noted under "Grade Determination." This is the **ONLY** accommodation that will be made for missing one quiz.

In the event that unusual circumstances cause you to be absent when a unit exam is administered, if you present your instructor with documentation of the circumstances, you will be given the opportunity to take a similar unit exam at the end of the semester, if necessary. This opportunity will be granted for only one exam per student. Detailed information about assignments and assessments can be found in Appendices B and C.

### **Calculator Use for XXXXX**

The focus of this course is the development of confidence working with basic mathematic skills. Though liberal use of a calculator is permitted for most topics, you are encouraged to use your calculator to **CHECK** answers after doing the arithmetic without the use of a calculator.

Individual instructors reserve the right to prohibit the use a calculator for a particular assignment being completed in class. An announcement will be made to all students when the instructor wants to focus on the development of a particular skill for which the use of a calculator would not be appropriate.

**NOTE: Quiz 2 (Integers) will be completed without the assistance of a calculator. You will not be able to use a calculator to check your work on that quiz. You will be allowed to use a calculator for all other quizzes and exams.**

The recommended calculator is a scientific calculator with buttons for operations, square and higher roots, squares and higher powers, fractions, and a  $\pi$  button. (This type of calculator can usually be purchased locally for under \$15.00) **Cell phones are not allowed to be used as calculators!** Note: The TI 83 or 84 is not required for this course, but will be required for all courses above XXXXX. The TI 84 (similar to the TI 83) is the calculator the author uses in the textbook in illustrations and descriptions of calculator use.

### **Policies and Regulations**

Provisions of the Student Guide to Policies and Regulations included in the Student Handbook will be followed in order to maintain the optimal learning environment sought by the College. Please secure a copy of the handbook and read it. The following highlights address some of the XXX policies and regulations as they pertain to this course.

#### **Drugs, Alcohol, and Tobacco**

The College is a Drug-Free Zone. No trafficking or use of drugs or alcohol will be tolerated. Tobacco use is not permitted indoors and is permitted only in gazebos located around the campus.

#### **Pagers and Cell Phones**

**No** cell phone use will be allowed in the classroom or the computer lab at any time. Please turn

cell phones **off** before entering class. Please discuss with your instructor any emergency need for the use of a pager to determine if an exception is appropriate.

### **Unauthorized Persons**

It is the policy of the College that only those who are registered for the course are permitted in the classroom. Children, family members, and/or friends are not allowed in the classroom at any time for any reason.

### **Honesty**

During quizzes and exams, each student is expected to do his/her own work. Cheating will not be tolerated. Violators of this policy will be reported and disciplined accordingly. Instructors are also bound by a code of academic integrity; your instructor has an obligation to uphold the standards established by XXX.

**Some** of the behaviors that are considered cheating are:

- Submitting any work as your own that has been done by another or with the help of another.
- Communicating with another student during a quiz or exam.
- Copying material from another student or other unauthorized source during a quiz or exam or for any assignment being graded. (When working with study groups has been recommended, the problems study group members complete together should not include those assigned that may be collected and graded unless authorized by the instructor. Collaborating on similar problems to review skills is appropriate.)
- Allowing another student to copy from your quiz, exam, or any assignment being graded.
- Using unauthorized assistance of any kind (notes, books, person, website, etc.) on any assignment being graded.
- Allowing someone to complete your work using the HLS software.
- Completing someone else's work using the HLS software.
- Providing or receiving a copy of a quiz or exam to be used in the course. Use of a cell phone or pager to transmit or receive information during a quiz or exam.

## **APPENDIX A**

### **IP GRADE**

The In Progress grade (IP) is a grade designed for use with developmental courses. A student who earns an IP will do so by demonstrating consistent effort and measurable achievement throughout the semester, as well as having excellent attendance. A student who is absent from class more than three times is not eligible to earn the IP grade. (Reminder: Arriving more than ten minutes late and/or leaving early may be considered "absent from class.") A student earning IP will complete a contract with the instructor detailing the requirements the student will need to meet in the following (full) semester in order to pass the course. A student who receives an IP at midterm should meet with the instructor immediately to discuss the contract as well as other options available.

NOTES: 1) Students repeating the course with an IP must enroll and pay tuition and fees when repeating the course. 2) IP is NOT a passing grade, and may be considered the same as the failing grade by those granting tuition reimbursement or "student" status (e.g. employers). 3) IP is recognized for one semester at XXX; if the student does not pass the course during the next full semester (Fall/Spring), the transcript will indicate F for the course grade. 4) A student can not earn IP more than one time for the same course.

## **APPENDIX B**

### **ASSIGNMENTS**

## Study Habits

Students taking XXXXX may have already been exposed to some of the math skills and concepts in this course, but may not have developed a thorough understanding, or did not retain their skills. Therefore, several course requirements have been included to guide you in developing study/work habits that can help you with learning and retaining math skills. Completing all course requirements will increase the likelihood that you will be prepared to be successful in this and future math courses.

## “Homework”

In order for you to be successful in this course, it is important that you take an active role in the learning process from the start. It is typically expected that students will spend about two hours of study outside of class for every hour in class. The course assignments are designed to guide you in using this time productively. “Homework” is often mistakenly defined as the “exercises” or “problems” at the end of a chapter or section in the textbook. (In this course you will have the option of practicing your skills with those exercises **OR** with the corresponding HLS sections using a computer.) Completing problems from the book or software is a vital part of your work outside the classroom, but it is only one part of your “homework.”

## Textbook

Before coming to class, you will prepare by previewing the sections of the book to be used in class. You will be required to read the objectives for each assigned section and complete a written “Preview” assignment (not until after class 3) according to directions that will be provided by your instructor. The course schedule identifies this requirement as “Preview Assignment.” These assignments will be collected and graded; they are to be turned in at the very beginning of class.

After class, you are expected to carefully read the text and work through the examples in each section. This is an indispensable step in the learning process.

As already mentioned, practice is a key to your success in this course. You will be assigned several exercises to complete from each section of your textbook; they are identified on the course schedule. The answers to all odd-numbered exercises are in the back of your text book so you can check your work. You should work on these problems until they are completely correct and you understand them. Many students find it helpful to work with other students in a study group. When working in a study group, you should focus on problems that are similar to those assigned so you can complete the graded assignment on your own. It is important that you ask questions in (or before) class about any problems that gave you difficulty. (REMEMBER, you may choose to replace this practice with the Certify mode of the appropriate HLS section.)

At least ten “homework practice” assignments will be collected and graded. Again, work from the book OR software will be accepted. The emphasis of the grading of homework will be on the work/steps shown. Students are to identify each assignment’s section, number each problem, copy each problem, and display all relevant work in a neat and organized manner. **No credit will be given for homework that is merely a list of answers.**

Several sections of practice exercises in the textbook end with questions that require you to apply what you have learned and write about it. On the course schedule, these questions are identified as **“Writing and Thinking about Mathematics Assignment.”** Your responses may be used as the basis for discussion in class, and may be collected at any time as part of a graded homework assignment. Writing and Thinking About Mathematics responses are kept in your notebook. These questions are in addition to your practice homework and are NOT replaced by choosing to use the HLS software.

## Software

The Hawkes Learning Systems (HLS) software has been installed on campus computers in

all libraries and learning labs for your use. The software that came with your textbook includes your non-transferable license number that will allow you to use the HLS program. (You may install the software on your own computer for convenient use; check computer requirements in your textbook.) Each time you use the software (even on campus) you will need your personalized access code; directions for registering your license number to acquire your personalized access code are in your textbook in the Preface.

The HLS software was selected as a powerful tool that offers instruction and guided practice to assist you through the learning process. It is an excellent resource for reviewing course material, getting instant feedback on practice exercises, and making customized practice tests.

You may consider using the Instruct and Practice modes of the software in addition to your thorough reading of the section in the textbook. The Instruct mode features an audio option; if you will be using this feature on campus, headphones are recommended. The Practice mode provides you with instant feedback about the correctness of your response and offers tutorial assistance to help you learn from your errors. The level of difficulty in the Practice mode can be adjusted so you can build your confidence as you make progress and select more challenging questions.

The course schedule page indicates that completion of the Certify section of an HLS lesson can be submitted for a homework practice grade instead of the corresponding exercises from the textbook.

If you choose to submit this work for collected/graded homework assignments you must fulfill the same requirements as mentioned above: identify each section, number each problem, copy each problem, and display all relevant work in a neat and organized manner. You will also need to submit the certificate which indicates that you completed at least 80% of the work correctly. The software is designed to reflect the mastery learning concept which means that you will be able to continue trying the assignment until you are successful. When your work is submitted with the certificate, you will be credited with 100% of the points for the assignment.

Strikes are recorded for incorrect responses, and if you acquire too many, you will be sent out of the Certify mode to learn the skills you need before trying again. You can attempt to certify as many times as necessary. The intent of using the software is to use the feedback you receive to help you work on these skills until your work is correct and you understand.

Again, the assignments required for this course have been designed to help you develop the skills you will need in order to be successful in the rest of your math courses. Take responsibility for your learning from the very start. Keep up with assignments, and get help when you need it. Attend all classes, and COMMUNICATE with your instructor regularly to get the most benefit from taking this course.

## **APPENDIX C**

### **ASSESSMENTS**

#### **Notebook**

Keeping an organized notebook provides a great resource for studying and reviewing for exams. Notebooks will be collected and graded on the days of the unit exams\*. A grading rubric will be provided to each student. The rubric will clarify the requirements for your notebook.

\* Any student who submits an excellent notebook will not have to resubmit that notebook; only one notebook grade will be used when calculating points earned.

#### **Quizzes and Exams**

Quizzes and exams will be used to assess student learning of skills taught in class and/or introduced through assignments. During any quiz or exam, only pencils and calculators are permitted. A cell phone is **not permitted** to be used as a calculator. Ordinarily, students may not leave the room during a quiz or exam. Students who do leave will be considered to have completed their work before they left, and their papers will be collected immediately. If an extreme emergency develops requiring you to leave, please talk privately with the instructor before leaving.

Seven **quizzes** will be administered during the semester. You must be present in class to take a quiz; there are **NO** opportunities to make up quizzes.

Four **exams** will be given during the semester – three unit exams and a cumulative final exam. In the event that **unusual** circumstances cause you to be absent and miss a unit exam, if you present your instructor with documentation of the circumstances, you will be given the opportunity to take a similar exam at the end of the semester. This opportunity will be granted for only one exam per student.

## **APPENDIX D**

### **TUTORING**

The college provides free tutoring services for students enrolled in XXXXX and XXXXX. Check the Learning Assistance Center's web page (XXXXXXXX) to see the tutoring schedule for each campus. This schedule sometimes changes during the semester, so check periodically. You are strongly encouraged to use this service early in the semester. This service is limited and tutors often need to work with several students in a group.

The HLS software that came with your textbook is a computerized tutorial that provides Instruction, Practice (with instant feedback and tutorial assistance), and Certification (to assess your progress).

It is recommended that you use this resource for tutorial assistance regularly in addition to using it for regular assignments. It is especially recommended that you complete the HLS software lesson, including video lesson, if you must be absent from class.

Each campus library will have a set of video tapes of mathematics lessons that correspond to the course topics. The tapes can be viewed on campus. Ask at the front desk of the library for the Developmental Math videos.

If you find you need additional help, you are encouraged to use a private tutor; it would be your responsibility to pay for the time of a private tutor. Your instructor may be able to suggest other resources. Talk with your instructor as soon as you feel the need for additional help.

## Course Schedule

The instructor reserves the right to modify the course outline and schedule. Any adjustments, including class sessions, content, and assignments, will be announced during class. If you miss class, it is your responsibility to find out about any changes prior to the next class.

\* Practice assignments are from Prealgebra, fourth edition, by D. Franklin Wright. Assignments begin on the indicated pages. Notations "odd, eoo, eto" indicate the exercises assigned for homework practice as follows: 1-7 odd = 1, 3, 5, 7; 1-9 eoo (every other odd) = 1, 5, 9; 1-13 eto (every third odd) = 1, 7, 13. No notation indicates "all" as in 1-4 = 1, 2, 3, 4.

**\* INSTEAD of the "Practice" assignments from the textbook, you are encouraged to complete the "Certify" mode of corresponding sections using your Hawkes Learning Systems (HLS) software. Completion of the software "Certify" section(s) accompanied by written work will be accepted for homework credit.**

\* "Writing and Thinking about Mathematics" assignments (found in textbook) are not part of the "Practice" assignment and are assigned even if using the HLS software option.

These assignments may not provide enough practice for you. Whether or not your instructor adds to the assignments, you may want to take advantage of additional practice problems in your textbook and/or on the HLS software.

Class	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
1	Course Introduction  How to Use Your Book and Software  (Whole Numbers 1.1-1.3 Independent Study)	7  21  43	1-61 eoo  1-3 & 5-37 eoo & 40-45  1-7 & 9-39 eto & 41-59 eto & 67- 73		Preview 1.4 - 1.5 before your instructor teaches during the second class.	When working with Chapter 1, refer to Chapter 10 if you need more help understanding perimeter and area. (Metric conversions are not included in XXXXX.)  ALWAYS preview the assigned sections <b>before</b> the next class. Preview by looking over/reading the sections and noting the objectives, vocabulary, and procedures that will be introduced.
2	Whole Numbers 1.4-1.5	59  75	1-29 eoo  1-49 eoo	Page 67: 31-33	Preview 1.6-1.7	

Class	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
3	Whole Numbers 1.6-1.7	89 99	1-91 eto 1-49 eto	Page 94: 100-101  Page 103: 50-52	Preview 2.1-2.2	HLS Chapter 1 Chapter Review "Certify" DUE:  (Required before Class 8) YOUR FIRST WRITTEN PREVIEW ASSIGNMENT (2.1-2.2) WILL BE COLLECTED IN CLASS SESSION 4.
4	<b>Quiz 1</b>  Integers 2.1-2.2	125 135	1-51 odd 1-57 eoo & 61-70 & 71-77 odd	Page 128: 53-55	Preview 2.3-2.5	Reminder: Calculators may not be used for Quiz 2. Practice computation with integers without one.
5	Integers 2.3- 2.5	147 163 171	1-85 eto 1-69 eoo 1-29 eoo	Page 153: 89-90  Page 163: 75-76	Preview 2.6-2.7	
6	Integers 2.6- 2.7	185 193	1-65 eoo 1-49 eoo	Page 196: 50-52		HLS Chapter 2 Chapter Review "Certify" DUE:
7	<b>Quiz 2</b>  Preparation for Unit 1 Exam					Recommended: Review for Unit 1 Exam with HLS Chapters 1 & 2 Chapter Review "Practice" or "Certify."
8	<b>Unit 1 Exam</b>	219 233	1-13 odd & 51-52 1-37 eto	Page 224: 71-72  Page 235: 53-54	Preview 3.1-3.4	

Class	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
9	Prime Numbers and Fractions (3.1-3.2 Independent Study) 3.3-3.4	243 255	1-2 & 3-57 eto 1-2 & 29-45 eoo & 59-63 odd	Page 259: 65-66	Preview 3.5-3.6	
10	Prime Numbers and Fractions 3.5-3.6	273 285	1-25 eoo & 31-34 & 35-75 eoo 1-8 & 9-39 eto & 41-49 odd	Page 278: 79	Preview 3.7	
11	Prime Numbers and Fractions 3.7	303	1-31 eto & 43-63 eoo & 69	Page 308: 75	Preview 4.1-4.2	HLS Chapter 3 Chapter Review "Certify" DUE:
12	<b>Quiz 3</b> Mixed Numbers, Ratios, and Proportions 4.1-4.2	327 341	1-55 eto 1-55 eto	Page 347: 61	Preview 4.3-4.6 SKIP 4.5	
13	Mixed Numbers, Ratios, and Proportions 4.3-4.6 (SKIP 4.5)	357 367 397	1-55 eto 1-2 & 3-45 eto 17-37 odd	Page 370: 47-48 Page 404: 57	Preview 4.5	HLS Chapter 4 Chapter Review "Certify" DUE:



Class	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
14	<b>Quiz 4</b>  Mixed Numbers, Ratios, and Proportions 4.5	379	1-4 & 7-43 eto & 57-65 eoo		Preview 5.1-5.3	
15	Decimal Numbers and Square Roots 5.1-5.3	429 443 461	1-29 eoo & 31-33 & 37-55 odd & 71 1-41 eoo & 46 1-37 eto & 39-51 odd		Preview 5.5-5.6	
16	Decimal Numbers and Square Roots 5.5-5.6	495 507	1-31 odd & 33-53 eoo & 61-71 odd 1-29 eoo	Page 499: 81-83	Preview 5.7	
17	Decimal Numbers and Square Roots 5.7	521	1-17 eoo & 21-29 odd & 43-49 odd		Preview 6.1-6.2	HLS Chapter 5 Chapter Review "Certify" DUE:

18	Percent 6.1-6.2	565  579	1-57 odd & 65-69 odd & 74  1-43 eto	Page 570: 75  Page 584: 61-63		HLS Chapter 6 Chapter Review "Certify" DUE:
<b>Class</b>	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
19	<b>Quiz 5</b>  Preparation for Unit 2 Exam					Recommended: Review for Unit 2 Exam with HLS Chapters 3. 4. 5. & 6 Chapter Review "Practice" or "Certify."  Prepare note card (no larger than 5" x 7" ~ front only) for unit exam.
20	<b>Unit 2 Exam</b>				Preview 7.1-7.2	
21	Algebraic Topics I 7.1-7.2	669  677	1-19 eto & 25-38 & 39-43 odd & 45-52  1-39 odd	Page 678: 41	Preview 7.3	Recommended: Review 4.5
22	Algebraic Topics I 7.3 (review 4.5)	681	1-15 odd		Preview 7.4-7.5	

23	Algebraic Topics I 7.4-7.5	693  703	1-4 & 5-15 odd & 21-25 odd  1-10 & 11-17 odd	Page 698: 41	Preview 9.1- 9.2	HLS Chapter 7 Chapter Review "Certify" DUE:
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Class	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
24	<b>Quiz 6</b>  Graphing in Two Dimensions 9.1	817	1-19 eto & 25-33 eoo & 34	Page 826: 49 (You will also need to complete # 47 on page 825.)		HLS Chapter 9 Chapter Review "Certify" DUE:  NOTICE: when using software, sometimes the axes are labeled (-5 to 5), indicating grid lines are $\frac{1}{2}$ unit apart.  Remember: Unless a scale is labeled, grid lines are presumed to be one unit apart.
25	Graphing in Two Dimensions 9.2	833	1-61 eoo			

26	<b>Quiz 7</b>  Unit Review  Preparation for Unit 3 Exam					Recommended: Review for Unit 3 Exam with HLS Chapters 7 & 9 Chapter Review "Practice" or "Certify."  Begin reviewing for Final Exam using Chapter Review "Practice" or "Certify" from any/all chapters.  Prepare note card (no larger than 5" x 7" ~ front only) for unit exam.
27	<b>Unit 3 Exam</b>					Continue reviewing for Final Exam using Chapter Review "Practice" or "Certify" from any/all chapters.
<b>Class</b>	Class Content and Textbook Section(s)	Practice Assignment from Textbook		Writing and Thinking about Mathematics Assignment	Preview Assignment	Notes
		page	exercises			
28	Preparation for Final Exam					Recommended: Continue reviewing for Final Exam using Chapter Review "Practice" or "Certify" from any/all chapters.  Prepare note card (no larger than 5" x 7" ~ front only) for final exam.
29	<b>Final Exam</b>					

## *Appendix B*

### Faculty and Student Questionnaires

## XXXXXX FACULTY QUESTIONNAIRE

*This questionnaire is part of a study being conducted by Amber Rust who is completing her doctoral studies with the Department of Curriculum and Instruction at the University of Maryland, College Park in collaboration with the XXXXX.*

Name: *(Remove name label)*

Study ID Number:

Date: \_\_\_\_\_

1.	What is your highest degree level? (Circle one.) <i>BS    BA    MS    MA    PhD    EdD    Professional    Other</i> a. If you circled "Other" please state the type of degree:
2.	What content area is (are) your degree(s) in? BS/BA _____ MS/MA _____ PhD/EdD _____ Professional/Other _____
3.	Not including this semester, how many semesters have you taught at XXX?
4.	Not including this semester, how many semesters have you taught XXXXX (lec and lab)?
5.	If you have taught at other post-secondary schools, how many semesters/quarters have you taught (not including this semester/quarter)? _____ (enter a number or Not Applicable) a. How many semesters/quarters have you taught mathematics? _____
6.	Do you have or have you had a K-12 teaching certification? _____ a. How many years, including the 2009-2010 school year, have you taught at the K-12 level? _____ b. How many years, including the 2009-2010 school year, have you taught mathematics at the K-12 level? _____ c. In what grade levels (K-12) have you taught mathematics? _____ b. Are you currently teaching at the K-12 level? _____

*All information collected is confidential and identification numbers designated just for this study will be used to label all data. The information provided will be used for reporting and presentation purposes and your name will not be used.*

## XXXXX STUDENT QUESTIONNAIRE

*This questionnaire is part of a study being conducted by Amber Rust who is completing her doctoral studies with the Department of Curriculum and Instruction at the University of Maryland, College Park in collaboration with the XXXXX.*

Name: (Remove name label)

Study ID Number:

Date: \_\_\_\_\_

Please mark the appropriate statement:

\_\_\_\_\_ I signed a consent form to participate in this study.

\_\_\_\_\_ I was in class the day Amber Rust explained the study and DID NOT sign the consent form.

\_\_\_\_\_ I was not in class the day Amber Rust explained the study and would like to learn \_\_\_\_\_ about it.

Please answer the following questions:

1.	What year did you graduate from high school (or get GED)?	
2.	What year did you take your last mathematics class in high school (or for GED)?	
3.	What was title of the last mathematics class you took in high school (or for GED)?	
4.	Not including this semester, how many semesters (part-time and full-time) have you attended XXX?	
5.	Is CSM the only college-level school you have attended since high school?	
6.	Approximately how many hours per week do you work to earn income?	

*All information collected is confidential and identification numbers designated just for this study will be used to label all data. The information provided will be used for reporting and presentation purposes and your name will never be used.*

## *Appendix C*

### Faculty Interview Questions



**First Interview Questions  
All Participating Faculty**

- 1.) How is it that you have gotten involved in teaching a developmental mathematics course?
- 2.) Do you ever teach XXXXX?
- 3.) How is it that you were assigned to teach XXXXX?
- 4.) What do you feel is the purpose for offering developmental mathematics courses?
- 5.) What is your experience with developmental mathematics students overall?
- 6.) What do you feel is the need that XXXXX addresses for your students?
- 7.) What do you see as the strengths and weaknesses that these students have, either the strengths and weaknesses of students in your section this semester or the strengths and weaknesses of developmental mathematics students in general?
- 8.) What is the most challenging part, and the most rewarding part, of teaching developmental mathematics students?

**Second Interview Questions  
Treatment Faculty Only**

- 1.) Generally, what do you think about the reading strategies you were asked to incorporate into your math lectures or lessons this semester?
- 2.) What was the most challenging aspect of using the reading strategies for you?
- 3.) Was any aspect of the reading strategies a pleasant surprise for you? Explain.
- 4.) Of all the reading strategies you were asked to incorporate, did you have a favorite reading strategy? If so, why? (You can choose more than one.)
- 5.) Of all the reading strategies you were asked to incorporate, did you have a least favorite reading strategy? If so, why? (You can choose more than one.)
- 6.) Do you feel that the students had a favorite reading strategy? If so, which one and why?
- 7.) Which reading strategy do you feel was the most effective in helping the students learn the material? Why? (You can choose more than one.)
- 8.) Which reading strategy do you feel was the least effective in helping the students learn the material? Why? (You can choose more than one.)

The following questions will be for each reading strategy:

- 9.) Did you implement this reading strategy?
- 10.) How did you implement the reading strategy? If you made a modification, please explain.
- 11.) Did you feel this reading strategy helped the students learn the math?
- 12.) Was some aspect of the implementation difficult? Why?

*Appendix D*

Samples of Reading Strategy Instruments

## Scrambled Solutions #1: Section 7.2

Directions: In the first column the scrambled steps for solving the equation are given. In the second column, write the steps in the correct order. In the last column, give an explanation for each step; include the principle/property used if appropriate in the solution process.

	Rewrite the steps in order	Explain
$-1 = z$	<b>1.</b>	
$2z - 2z + 2 = 3z - 2z + 3$	<b>2.</b>	
$2(z + 1) = 3z + 3$	<b>3.</b>	
$2 - 3 = z + 3 - 3$	<b>4.</b>	
$2z + 2 = 3z + 3$	<b>5.</b>	
$2 = z + 3$	<b>6.</b>	

## Textbook Reading Handout

**Directions:** As you read through this passage from your textbook (pp. 299-300) highlight in pink all the parts that you feel you understand well enough to explain to a classmate. Highlight in yellow all the parts that you do not understand or do not feel that you could explain to another classmate. When you finish, everything should be highlighted in pink or yellow.

### Objective 6

### Fractions Containing Variables

Now we will consider adding and subtracting fractions that contain variables in the numerators and/or the denominators. There are two basic rules that we must remember at all times:

1. Addition or subtraction can be accomplished only if the fractions have a common denominator.
2. A fraction can be reduced only if the numerator and denominator have a common factor.

Find the indicated algebraic sums or differences.

11.  $\frac{5}{c} + \frac{6}{c} + \frac{3}{c}$

$$\frac{14}{c}$$

#### Example 11

Find the sum:  $\frac{1}{a} + \frac{2}{a} + \frac{3}{a}$

#### Solution

The fractions all have the same denominator, so we simply add the numerators and keep the common denominator.

$$\frac{1}{a} + \frac{2}{a} + \frac{3}{a} = \frac{1+2+3}{a} = \frac{6}{a}$$

Now work exercise 11 in the margin.

12.  $\frac{2}{x} + \frac{3}{5}$

$$\frac{10+3x}{5x}$$

#### Example 12

Find the sum:  $\frac{3}{x} + \frac{7}{8}$

#### Solution

The two fractions have different denominators. The LCD is the product of the two denominators:  $8x$ .

$$\frac{3}{x} + \frac{7}{8} = \frac{3}{x} \cdot \frac{8}{8} + \frac{7}{8} \cdot \frac{x}{x} = \frac{24}{8x} + \frac{7x}{8x} = \frac{24+7x}{8x}$$

Now work exercise 12 in the margin.

**Caution:** Do not try to reduce the answer in Example 12.

In the fraction  $\frac{24+7x}{8x}$ , neither 8 nor  $x$  is a **factor** of the numerator.

The “common error” discussion on page 85 can help in discussing the algebraic expression in Example 12 and the fact that it cannot be simplified.

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